Ancient Mediterranean Agriculture: Part I
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ANCIENT MEDITERRANEAN AGRICULTURE*

PART I

BY ELLEN CHURCHILL SEMPLE†

GEOGRAPHIC CONDITIONS

Ancient Mediterranean agriculture had to adjust itself to a complex group of geographic conditions. It found a simple combination of climate, soil, and relief over a large area only in a few places like Egypt and the Po River Valley. In other districts the combinations were manifold within a small extent of country. Mountains dropped down to plains; a gravel-strewn soil bordered a fertile alluvium; a highland section of heavy rainfall sent down its streams to a semi-arid lowland; a limestone plateau, covered with a thin veneer of earth, overlooked a valley of deep rich soil; rainy winters alternated with long periods of summer drought, and the amount of the rainfall was unreliable. Agriculture was stimulated by the necessity of adjusting itself to these varied geographic conditions, and hence attained a precocious development which in many respects anticipated the best modern achievements.

MOUNTAIN RELIEF

Owing to the prevailing mountain relief, the Mediterranean countries suffered from a paucity of level land adapted

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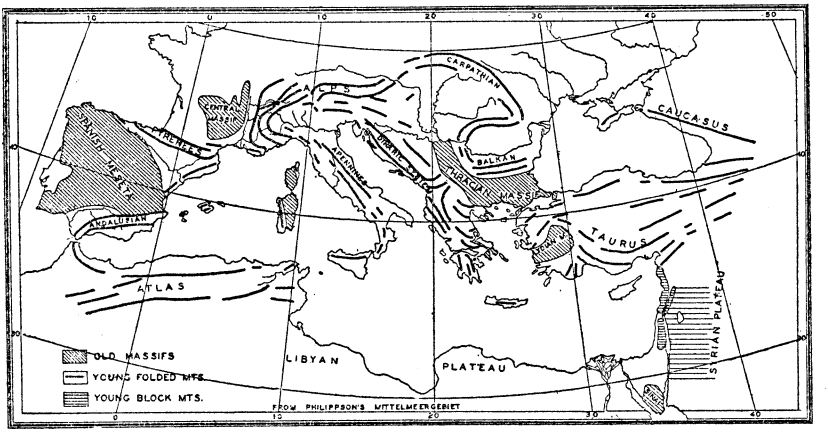
to tillage (see Map No. 1). Young folded systems with steep slopes, narrow valleys, and eroded canyons alternated here and there with old highlands of gentler slope. Coastal plains and interior lowlands were small and rare. Nearly the whole region was broken up into a series of narrow valleys opening out into deltaic flats, enclosed on three sides by hills or mountains. These were the garden spots of the Mediterranean. Here population concentrated, living off the produce of the small but fertile area, and securing its luxuries by sea-borne commerce. But population early



MAP NO. 1. MOUNTAIN RELIEF—MEDITERRANEAN BASIN

outstripped the local means of subsistance. The home fields were compelled to produce more by improved methods of cultivation. Mountain-sides were terraced to extend the arable area. Retaining walls protected the new-made fields from erosion, and constant manuring kept up the fertility of these shallow shelves of land. On the durable valley fields every method was applied to increase the yield; repeated fertilization of the soil, careful tillage, intelligent selection of crops suited to climate and soil, importation of foreign seed and foreign plants, painstaking seed selection, all combined to constitute a precocious form of intensive tillage.

CLIMATE

Climate also was a potent factor in speeding up improved agricultural methods. The Mediterranean region is approximately a climate unit. It is a region of winter rains and summer droughts, of warm summers and mild winters (see Map No. 2). The annual precipitation as a whole is

MAP NO. 2. ANNUAL RAINFALL—MEDITERRANEAN BASIN

moderate, but it varies greatly from one district to another (see Map No. 3). It declines from north to south, from highland to lowland, and from the west side to the east side of mountains, peninsulas and islands. It ranges from 60 inches or more on the Alpine slope near Trieste to 50 in Corfu, 27 in Patras, 21 at Candia in Crete, and 11 inches at Benghazi on the Cyrenaica coast of Africa.

It declines from 40 inches in Cephalonia on the west side of Greece, where the land lies exposed to the rain-bearing winds, to 16 inches in Athens 170 miles away on the eastern side but located in the rain-shadow of the Pindus Mountains; and it increases again to 26 inches in Smyrna on the west coast of Asia Minor.

MAP NO. 3. SUMMER RAINFALL—MEDITERRANEAN BASIN

It is not the amount of the rainfall, however, but its marked seasonal distribution which characterizes the Mediterranean climate; and no appreciable change in this climate has occurred, in historical times, according to the evidence. The Mediterranean maritime region, however, includes several divergent climatic provinces. The Aegean and Black Sea give access to the Scythian plains (Russia) which get their rains (12 to 18 inches) chiefly in spring and

early summer in time for the spring wheat crop. The Po Valley, owing to its northern location and encircling mountains, gets its heaviest rains in autumn and spring, with showers through the summer. Egypt is a land apart, a fluvial oasis stretched across the African desert, innocent of rain beyond the Nile delta.

The Mediterranean climate, by reason of its sub-tropical temperatures, winter rains, and summer droughts, caused winter to become the chief season of tillage, and summer a period of relative rest. For the sown crops of winter, which were aided by the mild winter temperatures, the rains usually sufficed; but owing to the variability of the annual precipitation and to the uncertain duration and intensity of the long summer drought, the Mediterranean peasant had to adjust his tillage to the constant threat of inadequate rainfall. Hence he resorted to dry farming methods, which involved an alternate year of crop and fallow, elaborate plowing and working both of the fallow and the crop land, and careful discrimination in the use of soils, those which were dry and those which were retentive of moisture. The method of soil improvement resulting from this pressure of climatic conditions was a form of intensive agriculture.

The summer drought, which increased in length and intensity from north to south and from west to east in the long elipse of the Mediterranean lands, necessitated irrigation for the cultivation of summer crops. These included many legumes, all vegetables, and also monsoon fruits which, in the course of time, were imported from the Orient and which required for their growth both heat and moisture. Irrigated tillage was also a form of intensive agriculture. It involved an expenditure of labor and capital in the construction of reservoirs and conduits; it necessitated frequent manuring of the irrigated fields which could be cropped all the year round; and it encouraged careful selection of seeds and plants in order to secure a fair return upon the valuable irrigated land. The mild winter temperatures of the Mediterranean region provided a long growing season which

repaid tillage and therefore was an incentive to increased effort. The only definitive checks upon the crops which might be raised were the amount of rain or available irrigation water and the quality of the soil.

SOILS

The ancient farmers recognized the importance of soils and distinguished many varieties. Interest in the quality of soil meets us in the earliest Greek literature. Odysseus, in the Isle of the Cyclops, observes that "the land might yield a very heavy crop and one always in season, for the subsoil is rich."[1] Homer in the *Iliad* speaks of "deep-soiled Troyland," "deep-soiled Thrace," "deep-soiled Phthia," and "goodly Elis,"[2]—a broad plain of loose Tertiary materials, overlayed by alluvium washed down from the Arcadian Highland. He knows "the fresh-ploughed field of rich tilth and wide," where "the upturned soil shows black."[3] One would have enjoyed touring Greece with that observant poet before the light of his eyes went out. Herodotus sweeps Egyptian land with the discerning glance of a farmer; he describes the soil of the Nile flood plain as "black and crumbling as if it were mud and alluvial deposit, brought down by the river from Ethiopia; whereas we know that the earth of Libya is reddish and somewhat more sandy, and that of Arabia and Syria is more clayey and flinty."[4] Libya and Arabia defined respectively the western and eastern borders of the Nile flood-plain, which alone constituted the Egypt of his time.

The ancients judged the fertility of soil by its color, according as it was black, dark, red, grey, or white; by its texture as fat or lean, heavy or light, dense and sticky or loose, compact or friable, gravelly, chalky or sandy, loamy or clayey; by its water content as wet, miry, moist, dry and

[1] *Odyssey*, IX, 136.
[2] *Illiad*, III, 73; XX, 485; IX, 328; XI, 685, 697.
[3] *Iliad*, XVIII, 541–548.
[4] Herodotus, II, 12.

parched; and finally by its natural vegetation.[5] They recognized various combinations of these qualities, as light loose, warm soil or cold, dense, clayey soil or deep, rich, friable soil. At an early date they appreciated the value of mixed soils, in regard not only to fertility but also to mechanical composition. Theophrastus apparently questioning many of the two thousand students who attended his lectures in the Lyceum of Athens, summarized the agricultural practice which they had observed in their widely scattered native localities. "They tell us to mix contrasted kinds of soils, heavy with light and light with heavy; thin soil with rich, and also the red (*terra rubra*) with the white; and all contrasted kinds with rich soil. For the mixture not only remedies defects, but also adds strength, no matter what kind it was. If you will mix with another soil that which is exhausted and unsuited to grains, it will bear again as if renewed."[6]

The ancients distinguished soils also by their location in valleys, at the base of mountains, or on the middle or upper slopes;[7] they recognized the relation of fertility and soil depth to the terrain, and therefore gave more manure to hillside fields than to valley land.[8] Moreover, they sowed thickly or scantily according to the quality of the soil.[9] "A fat good soil can bear heavier seeding than one which is sandy and light. However, they say that the same piece of land can take up more seed at one time and less at another time."[10] Rainfall, snow, exposure, winds, dew, sun, and especially cultivation were all recognized as affecting the

[5] Xenophon, *Oeconomicus*, XVI, 198; Herodotus, IV, 198; Theophrastus, *Historia Plantarum*, Bk. VIII, chap. ii, 8; chap. vi, 2–6; chap. vii, 5–7; Cato, *De Re Rustica*, 34; Varro, *Rerum Rusticarum*, Bk. I, chap. ix, 2–7; Columella, *De Agri Cultura*, Bk. I, chap. ii, 15; Bk. II, chap. ix; Vergil, *Georgics*, II, 177–258; Pliny, *Historia Naturalis*, XVII, 3, 4.

[6] Theophrastus, *De Causis Plantarum*, III, chap. xx, 3.

[7] Theophrastus, *Historia*, pt. II, chap. v, 7.

[8] Columella, II, chap. v, 1; II, chap. x, 6.

[9] *Leviticus*, XXVII, 16; Xenophon, *Oeconomicus*, XVII, 8–11; Columella, II, 9; Varro, I, chap. xliv, 1; Pliny, XVIII, 55.

[10] Theophrastus, *Historia*, Pt. VIII, chap. vi, 2.

yield of the soil.[11] Xenophon found nothing more profitable than to buy poor neglected farm land, renovate it by judicious cultivation, and sell it at an increased price.[12] Pliny dissented from a current opinion that the land of Italy was worn out, although the deterioration of field agriculture in his time was generally acknowledged.[13] As a matter of fact, these and other soils of the region have shown marked durability and powers of recuperation.

The soils of the Mediterranean region were in general young soils. They were allied in origin for the most part to the black earths of southern Russia. Conditions of climate and relief and the presence of wide-spread limestone formations combined to maintain the youth of these soils. The moderate or meager rainfall characteristic of large parts of the basin and its seasonal distribution tended to reduce the evil of leaching and hence to conserve the humus content of the soil. The limey constituents in the soil contributed to the same end by furnishing abundant supplies of calcium carbonate, which counteracted the natural tendency to acid formation and deflocculation; for a flocculated soil tends to preserve its fertility indefinitely. The limey content was constantly renewed from the underlying rock or it was supplied by the wash of earth on the ever present slopes. Moreover the prevailing mountain relief produced a slow rejuvenation of the soils by the steady transportation of fresh soil materials from the higher to the lower slopes, from mountain to piedmont, and from piedmont to valley or coastal plain. This process was accelerated by the erosive power of the wet weather streams, which carried off waste from the slopes and banks all the more effectively because the earth was baked and cracked by the summer drought.

The Tertiary terraces flanking many Mediterranean highlands consisted of weathered limestone, sandstone, marl,

[11] Theophrastus, *Historia*, Pt. VIII, chap. vii, 2, 6; IV, chap. iii, 7.
[12] Xenophon, *Oeconomicus*, XX, 22–26.
[13] Pliny, XVII, 3.

and clay, veneered with alluvium. They therefore provided successive levels of deep arable soil extending far up the mountains. But numerous slopes of pure Cretaceous or Tertiary limestones were covered with only a thin mantle of earth. These furnished considerable areas of shallow soil, poor and arid, because the rain water percolated through the porous underlying rock; and where precipitation was heavy, as in the karst districts of Italy, Illyria, Greece, Epirus, and the summit of the Judean Plateau, these conditions combined to develop the *terra rossa* or *terra rubra* of the ancients, infertile red clays, from which all alkalies had been leached out and the scant humus content had vanished.[14]

MARITIME INTERCOURSE

Another factor indirectly encouraged ancient Mediterranean tillage. This was the enclosed sea which everywhere opened up avenues of communication and along these Greek and Phoenician colonists and traders carried improved methods of tillage from old cultural centers in the east to the pioneer regons of the west. Agricultural exchanges characterized the maritime commerce from earliest times. Import and export of foodstuffs figured equally in the trade of ancient Palestine and ancient Spain. The result was the practice of propagating new seeds and new plants from over-sea lands. It was a trial and error method, but brought about a great diversification in the crops raised.

The ancient farmer learned by experience that climate and soil were big factors in the differentiation of fruits and grains; that a vine stock from Lebanon, for instance, gave a different grape on the slopes of Vesuvius or in the plain of the Rhone Valley. He became an experimental farmer, observing the results of every agricultural venture and drawing his conclusions accordingly. He was weak in theory but strong in practice. His methods were warranted to produce results, his result, the best yield possible for his particular

[14] Glinka, *Typen der Bodenbildung* (Berlin, 1914), 62–68.

type of climate and of soil. Hence he watched his neighbors' crops and was guided by their experience.[15] In our common parlance, he was a good "dirt farmer."

ANCIENT LAND UTILIZATION

Conditions of climate and relief gave rise to an elaborate system of land utilization. Plains were used for grain, hills for vineyards and orchards, mountains for forests and summer pasturage.[16] Undrained land in deltaic swamps or water-soaked lowlands were reserved for wet meadows, where hay was mown or cattle were grazed in summer.[17] Other undrained fields were planted to asparagus, to osiers and willows which provided material for baskets and wagon bodies.[18] Rich, moist valley lands were reserved for wheat, flax, and cabbage;[19] poor level soils were planted in various legumes which required little nutriment, like snail clover.[20] Red soil or *terra rossa* of the weathered limestone would yield good lupine and lentil crops.[21] All ancient authorities stress the importance of selecting certain soils for certain crops. Limestone or crystalline rock slopes with thin stoney soil, like the hills of Judea and Caria, were suited for figs and olives. They produced small trees but excellent fruit.[22] Mountain-sides of better soil, like volcanic ash overlying tertiary deposits of limestone and clay, were reserved for vineyards, which climbed the southward slopes up to 1000 feet or more, as on Mt. Massicus in Italy and Tmolus in Phrygia.[23]

[15] Xenophon, *Oeconomicus*, XVI, 3; Cato, *De Re Rustica*, VI, 1, 4: Varro, I, chap. xliv, 1.

[16] Varro, I, chap. vi, 2–6; chap. xxiii, 1–4.

[17] Ellen Churchill Semple, "Ancient Mediterranean Stock Raising," *Ann. Ass. Amer. Geog.*, XII (1922), 20–21, 30–31.

[18] Cato, VI, 4; Cato, IX.

[19] Vergil, *Georgics*, II, 203–225; Varro, I, chap. xxiii, 3.

[20] Varro, I, chap. xxiii, 2.

[21] Cato, 34 and 35; Columella, II, 10; Pliny, XVIII, 36.

[22] Theophrastus, *De Causis*, III, chap. vi, 6–8; Vergil, *Georgics*, II, 179–183; Columella, V, chap. x, 9.

[23] *Iliad*, III, 184; Strabo, XIV, 635; Vitruvius, III, 3; Vergil, *Georgics*, II, 97, 143; Pliny, XIV, 8, 9.

The base of a mountain range, where the land was enriched by the wash of the highlands behind, was considered the best site for a farm; here the soil was young and the fields were accessible to irrigation streams from the highlands, while the farm itself was protected from floods by its elevated site. A southward facing piedmont was the best.[24] Here the sun's heat was most effective by reason of insolation and the mountains behind warded off cold winds from the north, while air drainage protected orchards against untimely frosts. This was the general practice in the land utilization system of the ancients, but many exceptions to these rules were caused by local conditions of climate and soil.

SEASON OF TILLAGE

The distribution of rainfall made the mild Mediterranean winter the season of vegetative growth and the dry summer a period of rest, unless irrigation could supply the requisite moisture. Consequently for the ancient farmer, the winter half-year was preeminently the season of work. Most of the ploughing, harrowing, sowing, and planting had to be crowded into the ever shortening days between the autumn equinox and the winter solstice. The summer, after the early harvest in May or June, was the normal season of leisure. Hesiod, writing in the eighth century B.C., advised the Greek peasant to rest during the heat of the dog days and feast.[25] Therefore, ancient Mediterranean farm life, before the introduction of summer irrigated crops, presented a sharp contrast in its season of rural activity to the Tigris and Euphrates basins, where tillage depended upon the river floods caused by the spring and summer melting of the snows in Armenia; and it presented a like contrast to central and northern Europe, where the summer heat determined the season of tillage. But it accorded with Egypt, for the Nile floods, caused by the summer rains in the Highlands of Abyssinia, did not recede till autumn and therefore threw the big crops into the winter.

[24] Cato, I, 3; Varro, I, chap. xii, 1–3.
[25] Hesiod, *Work and Days*, II, 270–284.

FIELD AGRICULTURE CEREALS

The chief cereals of the Mediterranean Basin in antiquity, as today, were barley, wheat, and spelt (*zea, far,* or *ador*).[26] Rye and oats, essentially crops of northwestern Europe, were excluded in general from Mediterranean tillage because the climate was too dry. Rye was known to the ancient Greeks as a crop of Thrace and Macedonia,[27] whose northern location insured a heavier rainfall; and it was raised in the upper Po Valley in a mixed fodder crop.[28] Oats, known as a weed by Vergil, were a fodder crop fifty years later.[29]

Autumn was the sowing season throughout the Mediterranean Basin; it was called "the seed-time" in Greece and Italy. "The yearly cry of the crane from the cloud," winging his way southward, was the sign of approaching winter with its rains, and warned the farmer that all hands "must plough and sow early and late, on wet days and dry, that the grain lands may be full," says Hesiod, and "a bounteous harvest come with the white blossoms of spring."[30] To delay this autumn labor was to invite disaster. On the Roman farm the fall equinox was "the time to urge on the belated ploughs, while the dry soil allows it, while the clouds hang aloft."[31] The later advent of the autumn rains in Greece postponed the date of ploughing and sowing to October, and in Phoenicia and Palestine to November, when the first showers softened the soil preliminary to the heavy rains which began a month later. At the first sign of rain it was customary to "begin and sow the barley fields right into the showery skirts of frost-bound winter."[32] Greater caution had to be exercised with the wheat, which required immediate showers for its germination, but no excess mois-

[26] Pliny, XVIII, 19; R. Gradmann, *Die Getriedebau in Deutschland im römanischen Alterthum* (Jena, 1909), 32–39.

[27] Galen, VI, 514.

[28] Pliny, XVIII, 40.

[29] Vergil, *Georgics,* I, 77; Columella, II, chap. x, 32.

[30] Hesiod, *Work and Days,* 448–450.

[31] Vergil, *Georgics,* I, 213–215.

[32] Vergil, *Georgics,* I, 210–211.

ture; therefore it was sown after the barley, at successive intervals during the autumn to insure at least some yield.[33] In Greece, "all farmers look wistfully to the sky to see when the gods will send rain and allow them to sow." The rural maxim was: "Sow not on dry soil;" and the losses of impatient farmers pointed its moral.[34] In the eastern part of the Mediterranean Basin, where the growing season was short at best, the harvest was reduced or ruined if the autumn showers preceding the rains were tardy, or if the rainy season failed to end in late spring showers, which fortified the crops for their last period of growth. These were "the former and the latter rains" of the Bible for which the Hebrew farmer prayed.[35]

The crops grew quickly through the warm humid autumn, slowly during the winter, but matured rapidly under the increased warmth of spring. "Abundant harvests come with abundant heat" is Vergil's generalization for Italy; and in Greece Hesiod tells the farmer "to gather the ripe grain, when the snail seeks the shade of a leaf to escape the heat of the sun."[36] The harvest fell in May or June, according to the locality, and had ideal conditions of warm, drying weather. The ripe crops were never jeopardized as in lands of summer rains.

Less common was spring wheat or "three-months wheat," so called because it matured in three months after sowing in March. It was grown in Alpine Italy, Thrace, Sicily, southern Euboea and Boeotia, and was known to yield a hard, heavy grain as opposed to the light, soft winter wheat, which however was generally preferred for food.[37] On the Scythian plains of the Black Sea, both kinds were raised: "the hard wheat crops are those of spring, the soft ones those of winter; for soft kinds are exceedingly light" says

[33] Xenophon, *Oeconomicus*, XVII, 4–6; Theophrastus, *Historia*, Pt. VIII, chap. vi, 1; *De Causis*, IV, chap. iv, 7.

[34] Xenophon, *Oeconomicus*, VII, 2.

[35] *Deuteronomy*, XI, 14.

[36] Hesiod, *Work and Days*, II, 260–262.

[37] Columella, II, chap. vi, 38; Pliny, XVIII, 12, 20.

Theophrastus.[38] The spring wheat of Thrace was attributed by the ancients to the severe winters of that northern region, though the lingering spring rains may have been a factor. The heavy Boeotian wheat was doubtless spring-sown, as it is today, on the margin of the Lake Copais basin when the winter flood waters gradually receded and Lake Copais contracted; the rich lacustrine soil and high water table explained the superior quality of the grain.[39]

Millet and panic also were raised in various parts of the Mediterranean lands. As they required both heat and moisture, they found proper conditions in the irrigated fields of the Nile Valley and the Cilician lowland, where they were extensively cultivated.[40] In other districts they were planted at the vernal equinox, throve with a little irrigation, and matured after a short growing season. They were raised on a large scale as summer crops in the Scythian plains, in Campania of Italy, the northern part of the Po Valley and in southern Gaul,—all regions of summer showers or irrigation streams.[41]

LEGUMES

Besides cereals, several minor field crops which could stand the winter cold were planted in autumn and harvested in summer. But in the northern districts of the Basin, where the winters were rather severe but summers showery, and irrigation was easy, these were set out in the spring. Various legumes like lupines, beans, kidney-bean, various peas, chick-pea, vetch and lentils were usually sown in the autumn in Greece and peninsular Italy; but if they missed this seed time for any reason, they might be sown in the spring. Peas and lentils, which could ill endure the cold,

[38] Theophrastus, *Historia*, Pt. VIII, chap. iv, 5–6.

[39] Theophrastus, *De Causis*, IV, chap. ix, 5.

[40] Xenophon, *Anabasis*, I, chap. ii, 3.

[41] Theophrastus, *Historia*, Pt. VIII, 3; *De Causis*, II, 7; Vergil, *Georgics*, I, 216; Columella, II, chap. ix, 17; Pliny, XVIII, 10, 24, 25, 66.

were usually spring sown.[42] Vergil, whose principles of agriculture were reminiscent of his father's farm in the Mincio valley north of the river Po, advocated spring as the best seed time for beans, as frequent summer showers and abundant ground water provided all the moisture necessary, while irrigation was feasible at the critical blossoming time.[43] Sesame, like millet and panic, was a summer crop in both Greece and Italy and all three throve best by irrigation.[44]

Flax, which in time was widely cultivated, required a rich moist soil, which it was known to exhaust.[45] Soil, therefore, was the chief factor in its distribution. It was raised in Egypt for linen from the earliest times; in Palestine before and after the Jewish conquest,[46] where owing to its exhausting effects on the soil, tenants' contracts permitted it to be sown only once in seven years.[47] It flourished in the alluvial plain of the Phasis River in the land of Colchis, where Herodotus surmised that the culture had been introduced by Egyptian colonists.[48] It was known in Homeric Greece only by the imported fiber; later fine crops were grown in the fertile Tertiary plain of Elis,[49] but in general the climate and soil of Greece were too dry.[50] Flax was raised extensively in the Po Valley and the east coast of Spain where it gave rise to a finished linen industry.[51] It was sown in spring in northern Italy and probably in Colchis where summer rains were bountiful; but in autumn in Egypt and other semi-arid lands of the Eastern Mediterranean. The

[42] Theophrastus, *Historia*, Pt. VIII, chap. i, 3–4; chap. vi, 5; Pliny, XVIII, 30, 31, 33, 36, 37.

[43] Vergil, *Georgics*, I, 214–216.

[44] Theophrastus, *Historia*, Pt. VIII, chap. i, 1; chap. vii, 3; Pliny, XVIII, 22.

[45] Theophrastus, *De Causis*, IV, chap. v, 4; Columella, II, chap. x, 17.

[46] *Joshua*, II, 6; *Hosea*, II, 9.

[47] H. Vogelstein, *Die Landwirthschaft in Palastina zur Zeit der Mishnah* (Berlin, 1894), 50.

[48] Strabo, XI, chap. ii, 17; Herodotus, II, 105; IV, 74.

[49] Pausanias, V, chap. v, 2; VI, chap. xxvi, 4.

[50] H. Blummer, *Griechische Privatalterthümer* (Freiburg, 1882), 107–108.

[51] Pliny, XIX, 2.

fiber was used for various grades of linen, and the flaxseed for food both in Greece and Italy.[52]

DRY FARMING

The annual rainfall in most Mediterranean lands usually sufficed for the winter crops, but owing to wide variations in amount and in duration of the rains, tillage early developed dry-farming methods. Records of recurrent drought and famine meet us in the ancient history of Palestine, Syria, Cyprus, Crete, Asia Minor, Greece, Cyrenaica and Italy. These were often due to curtailment of the growing season. Amos makes Jehovah say: "I have withholden the rain from you when there were yet three months to the harvest."[53] This meant cessation of the rains in February and consequent death to the standing grain. Modern precipitation records of Jerusalem tell the same story. The "former rains" may begin any time between October 4th and November 28th, the first date promising a long growing season with timely germination of the seed in a warm soil, and the latter a short season and imperfect germination in ground chilled by winter cold. Moreover, the "latter rains" may cease any time between April 1st and May 27th, the former date meaning imperilled crops and the latter a full harvest. Italy, in 1922, lost so much of her wheat harvest, because the rains stopped early in May before the grain was filled out, that she had to lift the import duty on wheat. The amount of the rainfall is equally unreliable. At Jerusalem it fluctuates between 13 and 43 inches from a mean annual of 26 inches; at Athens, between 4.5 and 22.5 inches from a mean annual of 16 inches; in the Tunisian or Carthaginian district, between 13 and 26 inches from a mean annual of 17.75 inches; at Syracuse between 10 to 43 inches from an average 25 inches.

[52] Thucydides, IV, chap. xxvi, 8; Pliny, XIX, 3.
[53] *Amos*, IV, 7.

PLOUGHED FALLOW

These fluctuations are recognized by modern climatologists as normal phenomena on the margin of the arid belts; and they were taken into account by the ancient farmers. Dry farming methods were developed to a surprising degree, in Palestine and Greece in the 9th century B.C. or even earlier. Fields were regularly allowed to lie fallow in alternate years.[54] The effect was not only to rest the land, but also to accumulate in the soil a whole year's supply of moisture for the next crop. To accomplish this end, the idle field was kept constantly under cultivation; for working the fallow removed weeds and rendered the soil lighter and moister.[55] Three ploughings were considered imperative, and a fourth or even fifth was advocated. Hesiod calls the fallow "the guardian against death and ruin."[56] He mentions "a thrice-ploughed fallow in the fertile land of Crete."[57] Homer frequently mentions "the thrice-ploughed fallow," which seems to have been the early standard.[58] For the thin dry limestone soils of Palestine, the Hebrew Proverbs advise a fourth or mid-winter ploughing: "The sluggard will not plough by reason of the winter; therefore he shall beg in harvest."[59] Besides the three ploughings between spring and fall, Theophrastus advocates winter ploughing for light dry soils in order to enrich and moisten them.[60] Theocritus observes it was the custom in ancient Elis to "sow the seed in fallow land thrice, aye, four times broken by the plough."[61] Italy's best practice was the same: "That field yields best which twice has felt the summer's

[54] Vergil, *Georgics*, I, 71–72; Varro, I, chap. xliv, 3; Pliny, XVIII, 49.

[55] Theophrastus, *De Causis*, III, chap. x, 1; Xenophon, *Oeconomicus*, XVI, 11–15.

[56] Hesiod, *Work and Days*, 464.

[57] Hesiod, *Theogony*, 971.

[58] *Iliad*, XVIII, 542; *Odyssey*, V, 127; *Odyssey*, XIII, 32.

[59] *Proverbs*, XX, 4.

[60] Theophrastus, *De Causis*, III, chap. xx, 2, 6–7; *Historia*, Pt. VIII, 5.

[61] Theocritus, *Idyl 25*.

heat and twice the winter's cold."[62] Pliny advised five ploughings for dense soils; nine were needed to break up the hard clay land of Etruria.[63] The ancients regarded the fallow as a means of accumulating all the resources of the soil, of which water was "the chief aliment."[64] "Fruitful fields in turn now yield to man his yearly bread upon the plains, and now again they pause, and gather back their strength," says Pindar.[65]

The fields destined for fallow were ploughed first in September in time to catch the autumn showers; the second time in mid-winter to make the soil hospitable both to the winter rains and to the frost; the third time in spring before the last showers of the rainy season; and a fourth time in mid-summer.[66] This last ploughing, which was emphasized by all ancient authorities, had the effect of breaking up the surface enough to prevent loss of moisture by capillary attraction; it was rarely followed by harrowing. The standard was a bare, clean fallow. A field overgrown with thorns and weeds proclaimed the owner a slothful man, void of understanding, indulging in "a little sleep, a little slumber, a little folding of the hands to sleep," but destined to bitter poverty.[67] Xenophon urges ploughing in spring and repeatedly during the summer, in order to eradicate weeds and turn up the fallow to the sun.[68]

CHARACTER OF THE PLOUGHING

Ploughing moreover had to be thorough. Theophrastus and Cato considered it the essence of good tillage.[69] The first

[62] Vergil, *Georgics*, I, 42–49; Compare Theophrastus, *De Causis*, Pt. III, chap. xx, 6–7.

[63] Pliny, XVIII, 49; Pliny the Younger, *Letters*, V, 6.

[64] Pliny, XIX, 59; Theophrastus, *Historia*, Pt. IV, chap. iii, 7.

[65] Pindar, *Nemean Odes*, VI, 10–12.

[66] Varro, I, chaps. 29–32.

[67] *Proverbs*, XXIV, 30–34; *Hosea*, X, 12; *Jeremiah*, IV, 3.

[68] Xenophon, *Oeconomicus*, XVI, 12–14.

[69] Cato, 61; Theophrastus, *De Causis*, III, chap. x, 6.

furrows were run in straight lines and others were drawn obliquely across these to level the ridges.[70] A field was considered well ploughed when it was scarcely possible to detect in which direction the share had last gone.[71] Moreover, all clods were regularly broken up with the mattock, rake or hoe,[72] till no harrowing was necessary for the summer fallow or even for the sown field in autumn except to cover the seed, according to most authorities. Varro and Columella advise harrowing only in case of poorly tilled land.[73] On hillsides, furrows were drawn horizontally in order to prevent washing and to hold the moisture for the plant roots.[74]

The depth of the ploughing was determined by the nature of the land. In Syria and Palestine, where the underlying rock came near the surface, the native farmers used small ploughshares which made a shallow furrow, "lest the earth burnt by the sun, refuse a crop."[75] The Greeks appreciated the value of deep culture. It was customary in Megara every five years to dig down deep and turn up the subsoil as far as the water penetrated, because the rain carried the fertile elements down beyond the reach of the roots. The peasants of the rich lake plains of Thessaly had a digging implement called a *mischum* which did the work of a subsoil plough, turning up the earth from a considerable depth.[76] The comment of Ulysses on the subsoil of Sicily suggests that even the Homeric Greeks may have practised deep cultivation. The Romans considered that grain land had to be rich and well tilled for two feet down, not merely on the surface. Hence the fallow was ploughed deep, in order that the roots of the crop might readily penetrate.[77]

[70] Vergil, *Georgics*, I, 9.

[71] Varro, I, 9; Columella, II, 4–5.

[72] *Hosea*, X, 11; *Isaiah*, XXVII, 24–25; Vergil, *Georgics*, I, 164; Varro, I, 29, 2.

[73] Columella, II, 5.

[74] Pliny, XVIII, 49.

[75] Pliny, XVII, 3; Theophrastus, *De Causis*, III, chap. xx, 5.

[76] Theophrastus, *De Causis*, III, chap. xx, 4, 8.

[77] Columella, II, 2, 23.

Deviation from this alternate fallow system was considered permissible only when the winter grain crop was followed by a winter legume crop, which after an early harvest was turned under as a green manure.[78] But this three-field system had to be applied with caution. On a farm of 200 *jugera*, 100 *jugera* were sown in autumn; if a spring crop was raised, it was limited to 30 *jugera* so that nearly half of the land remained fallow. Only very rich, moist, volcanic soils, like those in the Neapolitan district where the ground water was high, were cropped every year.[79]

The fallow system persists in modern Greece. "Grain or fallow" or "grain or forage crop" describes the use of farm land there today, even in the excellent sandy loam of the Marathon plain.[80] In the Peloponnesus, the cropland lies fallow every second or third year, except in a few very fertile districts which are irrigated for gardens and currant plantations.[81]

YIELD PER ACRE

The yield per acre was moderate, despite all efforts at soil improvement through tillage and fertilization. Herodotus and Pliny cite returns of a hundred fold or more, but these were obviously exaggerations. The same applies to the sixty and thirty fold of the Bible, an impossible yield even for the scant sowing practised then as today on the poor soil of the Judean Plateau. According to reliable authorities, the maximum return known in Roman Italy about 50 B.C. was eight to ten fold. This was the yield of winter wheat from rich volcanic soils in eastern Sicily, and it amounted to 20 or 24 bushes to the acre.[82] A yield of

[78] Varro, I, 44; Theophrastus, *Historia*, Pt. VIII, chap. i, 4; *De Causis*, III, chap. xx, 7.

[79] Strabo, V, chap. iv, 3.

[80] Cyrus Hopkins, *Univ. Ill. Agri. Exp. Sta. Bull. 239*, Tables on pages 442, 444, and 456.

[81] A. Philippson, *Der. Peloponnesus* (Berlin, 1892), 540, 561–562.

[82] Cicero, *In Verrem*, III, 47, 116.

fifteen fold or 36 bushels of wheat to the acre was quite extraordinary and restricted to a few favored spots.[83] Old Cato, who a hundred years earlier tilled a farm of average soil in the Sabine hills near Rome, was content with five fold, which meant 10 bushels of wheat or 12 bushels of barley to the acre. This average fell to 8 bushels of wheat or less in the time of Columella (60 A.D.), when field tillage declined in Italy owing to excessive competition of foreign grain.[84]

ORCHARD AND VINEYARD CULTURE

Hardly less important than field agriculture was the orchard and vineyard culture of the ancient Mediterranean world. Every farm normally combined both branches of tillage in order to provide its own bread, olive oil and wine. This was the rule from the earliest times. To the ancient Jews, vineyards and orchards were essential features of sedentary agriculture as opposed to pastoral nomadism.[85] Every son of Israel wanted to sit under his own vine and his own fig tree.[86] Solomon purchased building materials for the Temple with wheat, oil and wine, all products of Palestine.[87] Grain fields, vineyards and orchards characterized the princely estates of the Homeric age in Greece.[88] Each farm, each district was practically self-sufficing.

But as maritime trade developed, as centers of population increased in size and multiplied, natural grain regions like Egypt and the Scythian plains became the dominant sources for bread-stuffs, though every small district and especially inland localities maintained some cereal culture against emergency times of war and piracy, when oversea supplies of grain became unreliable. With the curtailment of home-grown wheat fields, orchard and vineyard culture spread.[89]

[83] Varro, I, 44; Pliny, XVIII, 55.
[84] Columella, III, 3–4.
[85] *Jeremiah*, XXXV, 6–10.
[86] *I Kings*, IV, 25; *Isaiah*, XXXVI, 16.
[87] *II Chronicles*, II, 10, 15.
[88] *Iliad*, XVIII, 564–565; *Odyssey*, XXIV, 241–246; Hesiod, *Work and Days*, II, 250–254.
[89] Suetonius, *Augustus*, 42; *Domitian*, 7.

From the time of Solon, Attica was famous for its olive groves, the only remunerative crop on that poor limestone soil; Lesbos and Chios were noted for their vineyards. In the last decades of the Roman Republic, Italy looked like one great orchard,[90] while its mountains were mantled in vineyards. These branches of tillage yielded a big profit. They increased in regions of dense population or small arable area, where large returns from the soil were imperative. Such were the islands of the Aegean Sea and countless mountain-rimmed valleys, like that of Sparta. Certain localities, adapted by soil and climate to superior varieties of fruit or vine, specialized accordingly.

Ancient farmers made a radical distinction between sown and planted crops.[91] The latter were assigned to the hills, but were developed by close adaptation to conditions of prevailing winds, soil, exposure and air drainage. Their place in the complex system of land utilization was formulated in 313 B.C. by the Greek Theophrastus, but the practice was centuries older. Theophrastus says: "Use your rich soils for grains and thin soils for trees. Grains and all other annuals take the nutriment from the surface soil, which therefore ought not to be thin or of a quality to be quickly exhausted, as happens in a shallow layer of earth. But trees, equipped with long and strong roots, draw their nourishment from the depths. In rich soils, trees run to wood and foliage, but yield little or no fruit. Hence a thin soil is superior from both standpoints; it produces a balanced foliage and fruitage."[92] But this lean hillside soil required constant spadework to render it permeable by the roots, and manuring to provide plant food for the trees.[93]

The olive, fig, and vine, held a conspicuous place in ancient Mediterranean tillage. They seem to have been indigenous throughout the region, as they were equipped by nature to

[90] Varro, I, chap. ii, 6.
[91] Xenophon, *Hellenica*, III, chap. ii, 10; Cicero, *De Re Publica*, V, 2.
[92] Theophrastus, *De Causis*, II, chap. iv, 2–3.
[93] Theophrastus, *Historia*, Pt. II, chap. viii, 1.

withstand the summer drought; but their intensive cultivation, by which wild forms were domesticated and superior varieties were produced, spread from the eastern to the western end of the basin through the distributing agencies of trade and colonization. Vines and olive and fig trees survived the summer drought by reason of their elaborate root systems which penetrated down to the moisture conserved in the deeper layers of soil, and moreover spread out widely to gather in the maximum amount of moisture during the rainy season. The olive figured large in the domestic economy of the ancients. Its oil supplied the place of butter which was excluded by the poor pasturage of the Mediterranean lands, and it furnished the chief ingredient in the unguents and ointments for the skin which the strong dry winds of the Mediterranean summers made a necessity. Bread, oil, wine, figs, and grapes, eaten either fresh or dried as raisins and fig cakes, formed staple articles in the ancient Mediterranean diet. Wine was the universal beverage except for the beer used in Egypt and the mead consumed by the retarded mountaineers of central Spain.[94]

Orchards and vineyards flowered in early spring and produced their fruit in late summer or autumn. In ordinary seasons, they weathered the summer drought without irrigation, but in semi-arid regions or in especially dry years they demanded some artificial watering. Egypt, which is a special province of the Mediterranean region both from the climatic and physiographic standpoint, produced fruit trees and vines only by irrigation.[95]

NURSERY BEDS

Everywhere in the Mediterranean region these plants had to begin their life in nursery beds in order to develop an adequate root system, their prime requirement, before they should be set out in the fields. These nursery beds were

[94] Diodorus Siculus, V, 34.

[95] Xenophon, *Oeconomicus*, XIX, 3-10, Pliny, XVII, 14, 16; Vergil, *Georgics*, II, 348ff.

carefully prepared. Generally a trench was dug two or three feet deep and about as wide; stones or boulders were placed at the bottom for drainage, and covered with soil enriched with the proper kind of manure. The soil of the nursery bed and its exposure both to sun and prevailing winds was similar to that of the field into which the young trees or vines should be transferred,[96] "lest a sudden change of mother estrange the young plant," says Vergil. Shoots selected for propagation were the best varieties which could be found adapted to the local soil and climate.[97] They were irrigated morning and night until they had made a good start, and thereafter they were tended two to five years before being transplanted. Then they were removed with great care and rapidity to avoid mutilation of the roots and to prevent their getting dry.[98] Months or even a year before this important operation, holes were dug in the orchard or vineyard deeper than the trench of the nursery bed in order to facilitate the downward growth of the young roots.[99] Moreover, the young plant was then set out in the field with its south side indicated by a chalk mark, facing south, and its back to the north;[100] because, says Vergil, "So strong is the habit of infancy."[101] Vine stocks and trees set out in a rich plain were placed close together, because the abundant fertility of the soil would support the close planting;[102] but on the thinner soils of hillsides or mountains, they were given more room.[103]

Olive and fig trees were known to have especially wide-spreading roots.[104] For this reason, a law in ancient Attica prohibited a farmer from planting these trees within nine

[96] Cato, 45, 46, 48; Theophrastus, *De Causis*, III, chap. vi.

[97] Theophrastus, *Historia*, Pt. II, chap. v, 1.

[98] Cato, 28, 45.

[99] Mago quoted, Pliny, XVII, 16; Cato, 43; Columella, V, 10.

[100] Theophrastus, *Historia*, Pt. II, chap. v, 1.

[101] Vergil, *Georgics*, II, 272.

[102] Vergil, *Georgics*, II, 274–277.

[103] Theophrastus, *Historia*, Pt. II, chap. v, 6.

[104] Theophrastus, *De Causis*, III, chap. iv, 2; *Historia*, Pt. II, chap. iv, 6; Palladius, IV, 10, 25.

feet of his neighbor's boundary line, lest the roots should encroach upon the next estate.[105] The interval between olive trees in Italy measures from twenty-five to thirty feet according to Cato,[106] but the distance varied elsewhere according to the locality. Mago of Carthage prescribed an interval of seventy-five feet each way between the olive trees, or of forty-five feet where the soil was poor and exposed to winds.[107] This wide spacing undoubtedly reflected the low rainfall—10 to 14 inches—in the coastal plan of Tripolis, a region long famous for its olive groves, and in Mago's time (500 B.C.)[108] already in the Carthaginian sphere of influence. The trees there and also in the Atlas coast valleys were very large, because the oil was rich and ground water high. They were large also and widely spaced in the orchards of the Guadalquivir Valley; but there the interval may have been due to fertile soil and low rainfall, or to leave room for the grain crops regularly sown in the olive groves. The reach of the branches was considered the proper guide for the spacing.[109] The interval between pomegranates and myrtle was at least nine feet, and more for apples, pears, almonds and figs. Declivities required smaller intervals between the trees because the spread of the branches was less.[110] On windy sites it was found advisable to plant the trees close together for protection.

PRUNING

It was a general principle, recognized by Theophrastus and other writers, that barren trees lived longer than fecund ones, and those bearing scant fruit than those yielding much.[111] The cultivation of the orchard, however, aimed at

[105] Plutarch, *Solon*, 23.
[106] Cato, VI, 2.
[107] Mago, quoted, Pliny XVII, 19.
[108] J. P. Mahaffy, "The Work of Mago on Agriculture," *Hermathena*, VII (London, 1890), 29–35.
[109] Pliny, XVII, 17.
[110] Theophrastus, *De Causis*, III, 8.
[111] Theophrastus, *De Causis*, II, chap. xi, 1–3.

production of fruit, and not at the vigor of the tree. To achieve this purpose the ancients developed an elaborate system of pruning, thereby diverting the nutriment of the tree into the fruit. It was usual to keep the tree low and compact, since a tall growth involved waste of nutriment.[112] But in starting the young tree on its life course, climatic conditions forced the consideration of the woody growth until the tree was established. Experience taught that autumn pruning encouraged the vegetative growth and and spring pruning the development of fruit. Hence it was the rule to prune the poor, meagre vine in the autumn and the strong healthy vine in the spring. Moreover, the vine quicksets were cut down almost to the ground at the end of the first year and again at the end of the second year in order to develop roots and to encourage vigorous branching.[113]

The application of this principle meets us in Palestine among the Jews, who probably learned it from the resident Canaanites, a people already advanced in agriculture. The Bible instructs the Jews to plant all kinds of fruit trees but forbad them to eat the fruit of the tree till the fifth year of its growth. For the first three years, the yield was declared unclean; that of the fourth year was sacrificed in the Temple, but that of the fifth might be eaten.[114] The effect of this religious taboo was to discourage all pruning for fruitage and to encourage pruning for tree growth. The experience of American farmers in the interior of Washington teaches that hot, dry summers with intense sunlight stimulate premature fruiting.[115] This evil under similar climatic conditions in ancient Palestine was checked by autumn pruning. But the orchards once established were made to give as large a crop as possible, because of the relative

[112] Theophrastus, *De Causis*, II, chap. xii, 6; *Historia*, Pt. II, chap. vii, 2.

[113] Pliny, XVII, 35.

[114] *Leviticus*, XIX, 23-25; Josephus, *Jewish Antiquities*, IV, chap. viii, 19.

[115] L. H. Bailey, *The Pruning Book* (New York, 1914), 182, 185, 188.

paucity of good arable land and gentle slopes. The Bible forbad the Jews to destroy olive trees in war time, either wantonly or to use the wood in beseiging a city, because they were an asset for the conquerors.[116]

GRAFTING

The chief problem in the ancient Mediterranean orchard was to get the root system of a tree established. Young trees with shallow roots were at a disadvantage unless they were accessible to irrigation streams; but artificial watering often impaired the quality of the fruit. Hence grafting early became a feature of ancient fruit culture. A tree once established with a strong root system, such as wild olive, wild pear or wild apple, could be utilized by a fine grafted shoot.[117] According to Theophrastus, it was thus possible to upset the laws of nature, since the vine-dresser could produce black, white, and red bunches on the same shoot and could develop seedless grapes.[118] Experience also taught the ancients that grafted branches gave a yield true to type, while seedlings tended to revert to the wild variety or bear inferior fruit.[119] Grafting enabled the farmer to render barren trees productive and to introduce superior varieties.

OLIVE ORCHARDS

A large proportion of the orchard land apparently was devoted to olives. This was true in ancient as in modern times.[120] Pliny mentions fifteen varieties of olives, distributed from Syria to central Spain and from the base of the Alps to Africa. Italy raised the best fruit; Istria and

[116] *Deuteronomy*, XX, 19.

[117] Aristotle, *De Plantis*, I, 6; Cato, 40–42, 45; Varro, I, 40; Columella, V, 2, 8.

[118] Columella, *De Arboribus*, IX; Theophrastus, *De Causis*, V, chap. iii, 1.

[119] Theophrastus, *Historia*, Pt. II, chap. ii, 4–6; *De Causis*, II, 24.

[120] For Italy and Spain, *International Year Book of Agricultural Statistics* (Rome, 1922), Tables 38, 39; for Greece, *Report on the Industrial and Economic Situation in Greece* (London, 1927).

the Guadalquivir valley of Spain (Baetica) ranked next. Roman Africa "has been all but deprived of oil and wine," because both climate and soil were better adapted to grain production.[121]

Olive trees throve on a dry calcareous soil like that of Attica or Judea, or on a tenacious clay covering a slope, or on a mixture of clay and sand with a gravelly sub-soil.[122] Drainage was imperative. "Stubborn land and ungracious hills, fields of lean marl and pebbly brushwood welcome the long-lived groves of Pallas Athene," says Vergil,[123] speaking from the standpoint of the Alpine piedmont with its ample rainfall. Cato and Varro, familiar with the dry summers of Latium, advocate a dense warm soil for eight specified varieties of olive trees.[124] In the Guadalquivir Valley, with a fifteen inch rainfall, the orchards needed rich soil to retain moisture; but they yielded an excellent fruit in the Venafrum hill country of Campania, where the soil was gravelly and the rainfall amounted to 30 inches.[125] Hence it was a question of soil in relation to climatic condition. But exposure also came into the problem. The site of the olive grove might vary; but a location near the sea which reduced the frost hazard, and a westward facing slope were always preferable.[126]

Olive orchards required only moderate cultivation, because they were inured to the dry summers. It was necessary to prune, to manure, to plow or dig about the trees each year, and occasionally to bare the surface roots and clean away the suckers.[127] Improved methods of tillage which developed in course of time greatly curtailed the interval between planting the slow-growing orchard and reaping a

[121] Pliny, XV, 3–4.
[122] Columella, V, 8.
[123] Vergil, *Georgics*, II, 177–183.
[124] Cato, 6; Varro, I, chap. xxiv, 1–2; Theophrastus, *Historia*, Pt. II, chap. v, 7.
[125] Pliny, XVII, 3.
[126] Cato, 6; Varro, I, chap. xxiv, 1.
[127] Columella, V, 9, 15.

crop. Hesiod said that a man who planted a olive grove would never live long enough to eat its fruit; but young trees raised for five years in the nursery bed and cultivated after transplanting could be made to yield in seven years. But this was only under the best climatic conditions; in many localities the interval was longer.[128]

FIG ORCHARDS

Figs ranked next to olives as an article of food. They were grouped with bread and oil in the diet of the common people throughout the Mediterranean lands.[129] Cato advised that farm slaves should be fed chiefly on figs from the summer solstice, when the first crop came in, till late autumn.[130] Dried figs were eaten by the country folk all winter in Italy,[131] they were welcome as army rations in ancient Palestine,[132] and once served instead of grain for the forces of Phillip of Macedon in western Asia Minor,[133] doubtless owing to their sugar content.

Fig trees were adapted to a semi-arid climate, owing to their numerous spreading roots[134] and their scant leafage,[135] which lost little moisture by evaporation. They thrived best where the rainfall was light and the summer drought long; they preferred a sunny, well drained site on a hillside and a thin dry soil of weathered limestone or chalk, mingled with gravel or rocks.[136] Hence districts offering these natural conditions raised famous figs,—Caria and Phrygia in southwest Asia Minor where the "Smyrna figs" are raised today,[137] the island of Chios and even Paros with its soil of weathered

[128] Pliny, XV, 1.

[129] *Judges*, IX, 8–13; *Habakkuk*, III, 17; *Odyssey*, XXIV, 243–246; Plutarch, *Lucurgus*, XI.

[130] Cato, 56.

[131] Columella, XII, 14.

[132] *I. Samuel*, XXV, 18.

[133] Polybius, XII, 10.

[134] Theophrastus, *Historia*, Pt. I, chap. vi, 3.

[135] Pliny, XVII, 18.

[136] Columella, V, chap. x, 9; Palladius, IV, 10, 25–26.

[137] E. Banse, *Die Turkei* (Berin, 1916), 143–144.

marble,[138] and Attica which forbad the export of its figs, needing to conserve all its scant home-grown food supply.[139] Theophrastus must have had the infertile land of Attica in mind when he advocated a low or valley site for fig and olive orchard.[140] Italy, which acclimated many imported fig trees, planted one kind in a light chalky soil, and another in a rich or well manured soil.[141] Only the Megarean and Laconian fig were improved by irrigation, which was detrimental to all other kinds.[142] Hence the numerous varieties, twenty-nine in Pliny's time,[143] finally extended the possible selection of fig orchard sites; but lean hillsides held the preference.

CAPRIFICATION

Fig trees yielded their crop in June and again in September. The late fruit hung on the trees all winter to be harvested at will. The failure of the crop was a serious matter. Yet the domestic trees, except the varieties grown in middle Italy, and the Isthmus of Corinth, frequently made a diminished yield owing to the dropping of the immature fruit. A remedy for this evil was assiduously sought, Theophrastus tells us, and was found in caprification. This consisted in attaching to the branches of the domestic trees, which bore only female flowers, the fruit of the wild fig or caprifig, in order that minute gall wasps, *psenes*, which were generated therein, might crawl into the half-developed edible fruit of the domestic fig. The time for the operation was in late June and again in September, when the wild figs contained abundant male flowers with their pollen, and the insects were ready to emerge.[144] This natural process was properly

[138] Athenaeus, III, 6–9.

[139] Plutarch, *Solon*, XXIV.

[140] Theophrastus, *De Causis*, III, chap. vi, 6.

[141] Cato, 8, 1; 40, 1; Varro, I, chap. xliv, 4; Pliny, XV, 19.

[142] Theophrastus, *De Causis*, III, chap. vi, 6.

[143] Pliny, XV, 19.

[144] Aristotle, *De Animalibus*, V, 146; Theophrastus, *Historia*, Pt. II, chap. viii, 1–2, *De Causis*, II, chap. ix, 3, 6–15; Columella, XI, 2, 56.

interpreted by Theophrastus as cross fertilization of the fig fruit by an insect.[145]

The ancient Greeks thus improved upon nature's method, while following nature's example, at a very early date; they had doubtless learned from older cultivators of the fig in Syria and Asia Minor to tie bunches of the wild fruit on the domestic fig tree in order to insure a short journey for the insect to its destination. However, a like purpose was achieved by planting caprifigs in the fig orchards, the early variety near the early, and the late near the late kind, if the wild trees were set out on the windward side of the orchard so that the breezes might aid the flight of the little insects to the domestic trees.[146] This method was less troublesome but also less reliable, especially in late summer when the strong north winds might sweep the insects quite away.[147] These pollen-carriers were necessary to save the figs which were best adapted for drying; and caprification also improved the flavor of the fruit. Hence the insects were made the subject of careful study by the ancients. The *psenes* were found to have an enemy in the *cynipes*. The Greeks discovered a corrective for this state of affairs in *cancri* (literally crabs) which preyed upon the *cynipes* and which therefore were applied to the trees.[148] The *cynipes* and *cancri* have not been certainly identified, but the *psenes* are known to moderns as the *blastophaga grossorum*. They were colonized in California from Caria after Smyrna fig trees were introduced into that state between 1880 and 1890. There, also, the immature fruit dropped until caprification was practised.

PALM CULTURE

A similar method was used to fertilize palm trees and prevent their dropping the immature dates. It consisted in

[145] Theophrastus, *Historia*, Pt. II, chap. viii, 4.

[146] Theophrastus, *De Causis*, II, chap. ix, 5–6.

[147] Aristotle, *De Animalibus*, V, 146; Theophrastus, *Historia*, Pt. II, chap. viii, 1.

[148] Theophrastus, *Historia*, Pt. II, chap. viii, 3.

cutting off the spathe of the male palm and shaking out its pollen over the flower of the female tree. From its resemblance to caprification, this treatment of the palm was called *olynthazein* or "the use of the wild fruit." "In the latter case it was a genuine marriage; in the former, the same result was achieved in a different manner," says Theophrastus, anticipating Darwin by 2165 years.[149]

What the fig and olive were to the northern and eastern coast lands of the Mediterranean, the date palm was to the hot southern rim. It furnished nourishing fruit, cakes, wine, fiber and inferior wood. The Arab saying that the date palm flourishes with its head in fire and its feet in water indicates the conditions for its cultivation: tropical heat, aridity, saline soil, and irrigation. Though the tree grew at certain places on the European coast, it was either sterile or yielded immature dates.[150] The northern limit of its growth in ancient Aegean lands ran through Chios, Delos, Tenos and the southern end of Euboea, where it runs unchanged today.[151] The palm was fecund in Libya, Egypt, Phoenicia, Syria, Cyprus, and Crete; but yielded dates suitable for drying only in the Dead Sea Jordan Valley.[152] This depression, 682 to 1293 feet below sea level in the rain-shadow of the Judean Plateau, insured torrid heat and an arid climate with a scant eight-inch rainfall. Springs breaking out along the step-faults of the Jordan rift provided irrigation water. Hence the excellence and fecundity of the date plantations were unsurpassed, and made Jericho famous as "the city of the palms."[153]

VINEYARDS

The culture of the vine presented many problems of adjustment to geographic conditions. Maturing its fruit

[149] Theophrastus, *Historia*, Pt. II, chap. viii, 4; *De Causis*, III, 18, 1; Pliny, XIII, 7.

[150] Theophrastus, *Historia*, Pt. III, chap. iii, 5; Pliny, XIII, 6.

[151] Naumann and Partsch, *Physikalische Geographie von Griechenland* (Breslau, 1885), 410–411.

[152] Pliny, XIII, 6; Theophrastus, *Historia*, Pt. II, chap. vi, 2, 5, 8, 9.

[153] *Deuteronomy*, XXXIV, 3; *Judges*, I, 16; III, 13; Pliny, V, 15.

in August and September, it had to run the gauntlet of the dry summer months. Vineyards were planted on low moist ground in the semi-arid districts like Attica,[154] but on fertile slopes of hills and mountains in the better water parts of the region.[155] There was a choice also in the exposure. Most authorities advise a southerly aspect for the vineyards. Vergil condemns a western exposure,[156] but in some localities it was preferred to an easterly one. In northern sections, as in the Po Valley, another motive came into play owing to possible frosts. There vineyards regularly faced north or northeast; this exposure proved advantageous,[157] doubtless because the blossoming was retarded beyond the frost limit. Some planters selected the exposure according to the humidity of the locality. In a dry section, they faced the vineyard east or north to conserve the moisture in the plants, but in a humid region they planted the vineyard on a southward slope. Vines and trees to which dews were injurious were given an eastern exposure, that the sun might quickly evaporate the moisture; but those helped by the dew were made to face west or north in order to retain the precious moisture as long as possible.[158]

TRAINING OF VINES

The training of vines also was adjusted to climatic conditions. Where the ground moisture was abundant or where rare showers relieved the summer drought, vines were grown on posts or trellis or they were festooned from tree to tree in an *arbusta*.[159] The latter method of training was found chiefly in northern regions like Latium, Etruria, the Po Valley, and western and northern Hellas, where exposure

[154] Theophrastus, *Historia*, Pt. II, chap. v, 7.

[155] *Isaiah*, V, 1–2; *Jeremiah*, XXXI, 5; Vergil, *Georgics*, II, 36–37, 184–194.

[156] Vergil, *Georgics*, II, 298, 357.

[157] Pliny, XVII, 2.

[158] Pliny, XVII, 3.

[159] *Iliad*, XVIII, 564–565; Varro, I, chap. viii, 3, 5; Pliny, XIV, 3; XVIII, 35.

to the winds did not dry out the moisture of the plants. In arid regions like Africa, southern Spain, Sicily, southern Greece, Palestine, Syria, and parts of Asia Minor, the vines were allowed to trail on the ground, and only the grape-bearing shoots were supported by short forked sticks.[160] The advantage was obvious. Plants spreading out over the field presented the greatest possible surface to the heavy dews of high slopes; owing to their low position they were little exposed to the desiccating summer winds, and their foliage shaded the soil about their roots. This was the method of planting in ancient times and it may be seen today in such districts.

The vines suffered, however, from the depredations of field mice and foxes, "the little foxes that spoil the vines" mentioned in the Song of Solomon.[161] Varro said that in the island of Pantellaria each vine thus planted needed a mouse trap and a fox trap.[162] Aesop who wrote the fable of the Fox and the Sour Grapes lived in Phrygia in the sixth century B.C. He was accustomed to the ground-grown vineyards of southern Asia Minor and also to grape-eating foxes. Therefore the thirsty marauder of the fable was disappointed when he came upon a trellis vine, doubtless a novelty introduced by Greek colonists from northern Hellas; for the fox expected to find the grapes lying on the ground within his reach. Theocritus in one of his Sicilian idyls gives us a charming description of such a vineyard.[163] It is twilight. A little lad sits on the rough wall guarding the vines, which are laden with fire-red clusters; for it is summer when the springs have dried up and wild animals are thirsty. Below him two foxes are skulking; one goes along the fine vine rows to devour the juicy grapes, and the other is eating the lunch in the wallet which the boy has dropped on the ground at his feet. For the little lad, perched on the vineyard wall, is absorbed in plaiting a pretty

[160] Varro, I, chap. viii, 1, 5–7.
[161] *Canticles*, II, 15.
[162] Varro, I, chap. viii, 5.
[163] Theocritus, *Idyl I;* compare *Idyl V*.

locust cage from stalks of asphodel; and less care of his wallet has he, and of the vines he was sent to guard, than delight in his interesting task.

Vineyards were allowed to sprawl on the ground also in Liguria on the slopes of the Apennines and on the Mediterranean coast of the Rhone lowland; but the climatic reason here was different. The low situation was a protection against the fierce *mistral* or Circius wind, which swept down from the heights of the Cevennes Plateau with irresistible violence.[164] This method of planting may be seen in Languedoc and Berry today, where the vine rows are generally protected also by a wind-break of cypress trees. The severe summer winds of north Africa provided an additional reason for the ground planting there. Moreover the shoots were pruned away above the first branches and the vine stock thus kept low.[165] This ground planting had the further advantage of economy, because it avoided the cost of props and trellis. Altogether, differences in soil, climate and location, determined the method of cultivation. Wherever the soil was damp, the vine was by preference grown high, for the grapes when forming needed plenty of sun and the vine shoots by natural inclination climbed up the highest trees, where they were supposed to yield the finest juice.[166]

VINE-DRESSING

The vine-dresser also helped to conserve the moisture in the vine. He ploughed deep and cut away the surface roots of the plant in early spring in order to force the development of the lower roots running down to the underground moisture.[167] He pruned also to throw the strength into a few shoots and increase the yield of fruit,[168] but in so doing he also reduced the surface of evaporation. The same end was

[164] Pliny, XVII, 2.
[165] Pliny, XIV, 3.
[166] Varro I, chap. viii, 7.
[167] Columella, II, 2.
[168] Theophrastus, *Historia*, Pt. II, chap. vii, 2.

accomplished also by the habit of thinning out the leaves as the summer advanced and the vintage approached.[169] The remaining leaves in time shriveled in the dry heat and ceased their function of transpiration; but even this was not enough. At the end of August, when the summer's heat and drought reached their maximum, and evaporation was most intense, the soil of the vineyard was regularly reduced to a powder; the dust was tossed up into the air and allowed to settle all over the vines as a protection against the sun.[170] This process, which was called *pulveratio*, checked evaporation from the grapes, leaves, and from the earth about the roots, by preventing capillary attraction of the underground water. This same method was applied in Megara during the September heat to cucumber and squash plants. The fruits were made far sweeter and more tender by this natural conservation of moisture than by the alternative measure of irrigation.[171] In the hot regions of north Africa and southern Spain the vine-dressers covered the grapes with straw to protect them from sun and wind. On the other hand, in northern parts of the Mediterranean region, where the vintage came late and the grapes were occasionally caught by the September showers, the vine-dressers stripped the leaves from the vine to expose the grapes to the intermittent sunshine, and thus hastened their ripening, lest they should rot on the vines.[172]

DRY FARMING IN VINEYARDS

The cultivation of the ancient Mediterranean vineyards represented a thorough system of dry farming, designed to conserve the moisture in the soil and in the plant during the whole period of growth. This involved constant hoe and

[169] Xenopon, *Oeconomicus*, XIX, 18; Vergil, *Georgics*, II, 400.

[170] Theophrastus, *Historia*, Pt. II, chap. vii, 5; *De Causis*, III, chap. xvi, 3; Columella, IV, 28, 1; XI, 2, 60.

[171] Theophrastus, *Historia*, Pt. II, chap. vii, 5.

[172] Columella, XI, chap. ii, 61.

spade work during spring and summer.[173] Vergil's instructions required unremitting labor in the vineyards frequent plowings, banking up the earth repeatedly against the vine stalks, loosening the soils "thrice and again," breaking up the earth with hoe or mattock, "wheeling the steaming oxen between the vineyard rows."[174] That nothing might interfere with constant cultivation, all authorities from the Vergil advised against the planting of other crops between the vine rows. A system of clean culture was necessary. "Thou shalt not sow thy vineyard with divers seed, lest the fruit of the vineyard be defiled," says the author of *Deuteronomy*.[175] The purpose of this injunction was to facilitate constant cultivation of the vineyard soil, and to let the vine absorb all the moisture and nourishment in the ground. Columella sanctioned only the interculture of a short-lived green-manure crop, to be ploughed in.[176] A cover crop of legumes is common today in vineyards in Mediterranean regions which command sufficient water for irrigation; more common is a companion crop (*culture intercalaire*), planted for its own sake, which in Italy greatly reduces the yield of the vineyards.[177]

The ancients considered viticulture one of the most profitable branches of husbandry.[178] The yield of the vineyards seems to support this opinion. Some parts of Italy yielded 300 amphora of wine to the *jugerum* or 3100 gallons to the acre, equivalent to 19,000 bottles. This was the return in the Faventia district at the northern base of the Apennines near Bologna. The Ager Gallicus on the Adriatic coast of Umbria yielded 200 amphora to the *jugerum* or 2000 gallons to the acre.[179]

[173] *Isaiah*, V, 6; Hesiod, *Work and Days*, II, 250–254; *Odyssey*, XXIV, 224–226; Cato, 33.

[174] Vergil, *Georgics*, II, 398–400.

[175] *Deuteronomy*, XX, 9.

[176] Columella, XI, chap. ii, 60.

[177] *International Yearbook of Agricultural Statistics* (Rome, 1922), Tables 34 and 37

[178] Columella, III, 3.

[179] Varro, I, chap. ii, 7.

It was the wine-making connected with the vineyard culture which gave the large profit. Hence this twin industry was highly developed on small mountainous islands and peninsulas, and there it produced famous wines. Some of the best wines of the Grecian world came from Chios, Melos, Lesbos, Thasos, Ikaros, Andros, Naxos, Peparetos, Cyprus, and the Cnidos peninsula. All these islands had a large export trade.[180] In Italy the famous Falernian wine grew on the southward facing slopes at Mt. Massicus, where a thick soil of weathered volcanic rock overlay limestone strata. Vesuvius and Aetna, the Alban Mountains, and other volcanic districts produced superior wines.[181]

The earliest wine of great celebrity, lauded in the *Odyssey*, came from vineyards on the seaward slope of the Ismarus range, which traces the southern coast of Thrace. It was red and "honey-sweet" with a fine bouquet, and so strong that it had to be diluted with twenty parts of water.[182] This same district in Pliny's time produced a wine that could stand dilution with eighty times its volume of water.[183] Phoenician seamen, half traders, half pirates, put into the ports of Homeric Greece and sold choice wines from vineyards spread like a carpet over the Mediterranean slope of the Lebanon Mountains. These were the solace of the tired farmer, as Hesiod sings their praise. "At the height of summer when the grasshopper sounds his shrill note, when the heat is greatest and the skin is parched and dry, under a shady ledge of rock with a bowl of Byblian wine, three-fourths water, let me rest by an ever-flowing spring."[184]

[180] Pliny, XIV, 4, 9.
[181] Strabo, V, chap. iii, 1; chap. iv, 3; XIII, chap. iv, 11.
[182] *Odyssey*, IX, 208.
[183] Pliny, XIV, 6.
[184] Hesiod, *Work and Days*, 582–595.

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ANCIENT MEDITERRANEAN AGRICULTURE

Part II. Manuring and Seed Selection*

By Ellen Churchill Semple

The essence of ancient Mediterranean agriculture was the improvement of the soil, both in its mechanical and chemical composition. Working the land accomplished the first; manuring, the second; the biennial fallow contributed to both ends, while conserving the precious moisture in the soil.

Despite the fallow, overcropping was a persistent danger owing to the highly specialized utilization of the land, which arrested the development of crop rotation; owing also to the small amount of arable land rendered available by conditions of climate and relief. Olive groves were made to support a grain crop in alternate years; the *arbustum* field often yielded a second harvest between its vine-draped trees. The irrigated land with its summer and winter crop was doubly taxed and had to be doubly compensated; for the soil sends in its bill for every pound of plant food which is taken out.

MANURING

Hence the ancients developed the art of manuring to a surprising degree, in order to get a maximum yield from the limited tillage land and to replenish the nutriment in exhausted fields. In Palestine during the Mishnah period, irrigated land which was cropped twice annually was manured a second time before the summer seeding.[1] Everywhere irrigated hay meadows, which were mown three or four times a year, and alfalfa fields which yielded four or five harvests had to be amply fertilized at the planting.[2] Moreover, in years of heavy rains when soil moisture

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[1] H. Vogelstein, *Landwirthschaft in Palästina zur Zeit der Mišhnâh.* (Berlin, 1894), 24.

[2] Cato, *De Re Rustica*, 40; Varro, *Rerum Rusticarum*, I, 29; Pliny, *Historia Naturalis*, XVIII, 43 and 67.

was abundant, the farmer found he could avoid the economic waste of the fallow by judicious fertilization and some rotation of crops.

Without science the ancients evolved a scientific system of manuring, which became a conspicuous feature of their intensive tillage. They discriminated between various manures as to strength, and their relative value for different crops and different soils. Without chemistry they learned to conserve the important chemical elements of farm manure; and without bacteriology they learned how to get the maximum result from the bacteria in their compost heaps and their legume crops. They apportioned the amount of the manure to the quality of the soil, and in their gardens they practiced "head-fertilizing" (*kopfdüngung*) like the modern Japanese, feeding the individual plant rather than enriching the whole field.

Burdened with the labor of conserving the nutriment and moisture in the soil, the ancients looked with envy upon the easy tillage processes of Babylonia and Egypt. In the Tigris alluvium, "cultivation of the land consists in letting the water lie on it as long as possible, so that it may deposit much silt."[3] Herodotus considered that the Egyptians of the Delta garnered the fruits of the earth more easily than all other people, for they escaped the endless toil of plowing, harrowing, hoeing and fertilizing which other men had to perform to obtain a crop of grain.[4]

ASHES PRIMITIVE MANURE

The first lesson in soil compensation was forced upon the peasants' notice. Stone Age cultivators burned the forests to clear the land, because their blunt axes made slow work of felling hardwood trees. Ashes were found to enrich the ground and adopted as the first obvious fertilizer in the Mediterranean countries as elsewhere. The ancient Jews set fire to briers, thorn bushes and other scrub growth.[5] It was a common practice everywhere to burn the stubble of the previous crop on the land

[3] Theophrastus, *De Historia Plantarum*, VIII, 7, 4.
[4] Herodotus, II, 14.
[5] *Exodus*, XXII, 6; *Isaiah*, IX, 18.

to clear the fields and destroy the weeds.[6] However, this was an uneconomic method of converting the vegetable waste into fertilizer, because it dissipated the volatile elements like nitrogen and moisture; so most of the straw was utilized in other ways. But Cato advised the vine-dresser to burn the prunings of the vineyard on the spot and plough in the ashes to stimulate growth.[7] The advice was sound since wood ashes supply lime, potash and phosphoric acid to the soil; and it is exactly the small shoots and twigs which contain these chemicals in great amount.[8]

The principle of applying various animal and vegetable refuse to the soil originated with the beginning of migratory agriculture. The droppings of the flocks and herds about the nomad camp or in the open pasture revealed their power to enrich the land. The invention of manuring was ascribed to various gods and heroes, notably to King Augeas of Elis and to Hercules,[9] whose labor of cleansing the Augean stables by turning a river through them might be interpreted as the simultaneous application of irrigation and barnyard manure, a common practice among the ancients. The dunghill meets us in the courtyards of Ulysses and Laertes his father;[10] it was very ancient among the Jews who probably learned its value from the local Canaanites.[11] They carried all the manure of Jerusalem from the city by the Dung gate to the gardens outside.[12] The power of dead bodies to fertilize the ground after a battle or execution was known to the Greek Archilochus by 700 B.C.[13] and even earlier to the Jews.[14] Jeremiah emphasized the value of bone-dust,[15] and Deuteronomy directed the blood of slaughtered animals to be poured out on the ground, a practice which persisted for centuries.[16] The tragic

[6] *Isaiah*, V, 24; Xenophon, *Oeconomicus*, XVIII, 2; Vergil, *Georgic I*, 84.
[7] Cato, 37.
[8] W. P. Brooks, *Agriculture* (Springfield, Mass., 1905), II, 282.
[9] Pliny, XVII, 6.
[10] *Odyssey*, XVII, 297–299; XXIV, 225.
[11] *I. Samuel*, II, 8; *II Kings*, IX, 37.
[12] *Nehemiah*, II, 13.
[13] Plutarch, *Marius*, XXI.
[14] *Jeremiah*, IX, 22; XVI, 4; *II Kings*, IX, 37.
[15] *Jeremiah*, VIII, 1–2.
[16] *Deuteronomy*, XII, 16, 24; XV, 23; Vogelstein, *op. cit.*, 19.

fertility of old battle-fields belonged to the spot where Caius Marius wiped out the Teutonic horde at Aquae Sextiae in 102 B.C. "They say that the soil, after the bodies had rotted and the winter rains had fallen, was so fertilized and saturated with the putrefied matter which sank into it, that it produced an unusual crop the next season."[17] This effect was doubtless observed wherever men fought and tilled the land, from Megiddo to Flanders field.

"I sometimes think that never blows so red
The rose as where some buried Caesar bled."

FARM MANURES

The main source of animal manures was in the flocks and herds, whose value came largely from the dung to enrich the soil, according to Varro.[18] To maintain a proper balance between live stock and crops was difficult for the Mediterranean farmer, because the long summer drought necessitated keeping his animals for five or six months every year on the mountain pastures. Hence nearly half their manure was lost to the home farm. The amount available for the fields was limited to that provided by the few stall-fed oxen, asses and mules kept on the farm as work animals during summer; and by the returning flocks and herds which were pastured during winter on the home land. It was customary to fold them at night on the meadows, shifting them systematically, so that their droppings were evenly distributed. Their fresh manure insured a good stand of grass.[19] This method of applying the manure saved waste of organic material and of labor, but was best suited to meadows. For grain crops old rotted manure was best. The dunghill possessed special importance in dry countries like Palestine, Syria, Asia Minor and Greece, because it supplied humus to the soil. This element of plant food is always scant in clean-cultured fallow fields and in the thin herbage of semi-arid soils. To husband his manure was the farmer's first duty. Xenophon criticized peasants who failed to collect

[17] Plutarch, *Marius*, XXI.

[18] Varro, *R. R. Praefatio*, 4.

[19] Cato, 30; Columella, *De Agricultura*, II, 15, 9; Pliny, XVIII, 53; Vogelstein, *op. cit.*, 19–21.

dung.[20] Gathering it from stall and sheepcote was a regular task of the farm of Ulysses in Ithaca.

Greeks and Romans employed human excrements and the dung of cows, horses, asses, sheep, goats, swine, poultry, pigeons and various other birds. The Jews used the manure of these animals and also that of camels, but from human sources only the urine, which was applied in diluted form to the land.[21] These several animal manures were known to possess various degrees of efficiency, because they had been tested for ages and their relative values estimated, as Pliny states.[22] The surprising fact is how closely the ancient estimates agree with the results of chemical analyses made in modern agriculture laboratories, though the ancient authorities differed in details from each other.

Theophrastus ranks manures in point of richness or concentration as follows: (1) human excrements, (2), that of swine, (3), of goats, (4), of sheep, (5), of cows and oxen, (6), of beasts of burden or horses, mules and asses. He adds that these are different from one another and need to be differently applied.[23] He explains that manure of beasts of burden is "bad because it is most apt to lose its moisture."[24] This was true if the manure was placed only half rotted in a dry soil during a dry season, such as Attica provided.

The Roman authorities considered bird and chicken manures the richest, especially the droppings in dovecotes and aviaries; but they ranked low the excrements of ducks and geese,[25] a significant evidence of their close observation. In this opinion modern agricultural chemists concur. Poultry manure combines the solid and liquid elements with a minimum loss of the latter, which contains most of the nitrogen, while the solid matter contains large percentages of potash and phosphoric acid. Pigeons' manure is the richest; hens' manure stands next. Much

[20] Xenophon, *Oeconomicus*, XX, 10; Cato, 5.
[21] Vogelstein, *op. cit.*, 18–20.
[22] Pliny, XVII, 6.
[23] Theophrastus, *Hist. Plant.*, II, 7, 4.
[24] Theophrastus, *De Causis Plantarum*, III, IX, 2; *Hist. Plant.*, VII, 5, 1.
[25] Varro, I, 38; III, 7; Columella, II, 15.

lower comes ducks' manure, and that of geese ranks far down in the scale.[26] The differences are largely the result of different feeding; pigeons and poultry have concentrated food. The ancients, too, recognized that the feed of animals affected the quality of the manure. For instance, cytisus or snail clover, a popular legume fodder lauded by Columella, was thought to enrich all animal excrements.[27]

Varro's list, quoted from Cassius (40 B.C.) who probably relied on Mago, is as follows: (I) Manures of birds and fowls. (II) of human beings. (III) That of goats, sheep, swine and asses. (IV) That of horses and draught animals fed on barley. This, however, was the best for meadows, because it stimulated the herbage.[28] Columella accepted this classification as to groups; but for farm dung he ranked the ass first, sheep second, goats and horses third, and swine lowest.[29] Modern experiments corroborate these ancient estimates, especially for swine dung and human manure. The former is rich in phosphoric acid but poor in nitrogen, the element most needed by Mediterranean soils; the latter contains high percentages of nitrogen and phosphoric acid. It was so concentrated that Columella advised its being diluted or mixed with farm refuse, lest it burn the soil. When properly handled, it was excellent for vines and fruit trees, which therefore ought to be planted near the bagnios. In undiluted form it was good for poor sandy land.[30]

COMPOST HEAP

The chief dependence of the ancient farm was the manure pile. Therefore it received the best care. It was kept preferably in a water-tight cemented pit covered over to prevent loss of its moisture by drainage, leaching or evaporation, and was kept a year to rot before being placed on the land.[31] Straw, leaves, weeds from the fields, reeds and sedges from swamps or willow

[26] W. P. Brooks, *op. cit.*, II, 233-234.
[27] Pliny, XVII, 6.
[28] Varro, I, 38.
[29] Columella, II, 15.
[30] Columella, I, 6; II, 16; V, 10; Pliny, XVII, 6.
[31] Columella, I, 6; Pliny, XVII, 8.

plots were bedded under the farm animals,[32] and when trodden down added to the bulk and humus value of the manure,[33] beside conserving the urine. Isaiah speaks of "straw trodden down for the dunghill."[34] Into the compost heap went every form of organic refuse,—chaff, husks, pods, dead leaves, ferns, bean stalks, lupine straw. Columella added to this list weeds from the hedgerows, ashes, sewage and every kind of waste; and he emphasized the value of vegetable refuse on farms without cattle.[35] Xenophon found that weeds gathered from the fields and allowed "to rot in stagnant water made good manure to gladden the field."[36] To these various organic ingredients of the compost heap salt was added in Palestine. "Salt that has lost its savour is fit neither for the land nor for the dunghill."[37] Its value lay in its power to retain moisture, retard decomposition, and react on certain inert compounds, so that their lime and potash were more available.[38]

When the contents of the compost heap were well rotted, they were carted out, spread on the land, and ploughed in promptly to conserve moisture. This was done in Italy after a rain in September for an autumn crop, and for a spring crop in late winter when the ground was still wet.[39] There was a period when the manure was at its best. If too new or imperfectly rotted, it burnt the seed and the roots of trees;[40] if kept longer than a year it lost strength.[41] Concentrated manures, if undiluted or applied in excess, were likely to burn and dry out the soil. "The dung most recommended is that which is mixed with litter," is the generalization arrived at by Theophrastus;[42] for the ancients like the

[32] Cato, 5 and 37.
[33] Theophrastus, *Hist. Plant.*, VII, 5, 1.
[34] *Isaiah*, XXV, 10.
[35] Vogelstein, *op. cit.*, 19; Cato, 5 and 37; Columella, II, 15.
[36] Xenophon, *Oeconomicus*, XX, 11.
[37] *Luke*, XIV, 35.
[38] W. P. Brooks, *op. cit.*, II, 315.
[39] Cato, 5; Pliny, XVIII, 53.
[40] Pliny, XVII, 46.
[41] Columella, II, 15.
[42] Theophrastus, *Hist. Plant.*, VII, 5, 1. Compare Xenophon, *Oeconomicus*, XVIII, 2.

moderns recognized the effect of litter in diluting manure,[43] and they apparently adopted a rule for the proportion of bedding to be used. "Where sheep furnish a cartload of manure, the larger cattle should furnish ten loads; otherwise it is clear proof that the husbandman has littered his animals badly."[44] A standard bulk gave a standard strength, so far as this was affected by the litter and not by the kind of dung. Very rich manures, like human excrements, which ferment quickly, were regularly diluted.[45] Bird and pigeon guano was powdered and thinly strewn over field and garden,[46] as it is today for the same reason.

A study of the treatment and application of animal manures by the ancients reveals a painstaking adjustment to climatic conditions, especially to the long summer period of warmth and drought, when the soil contains insufficient moisture for the decay of organic matter. Stable manure rots with great difficulty on or in land which contains scant moisture, because the necessary bacteria do not develop there in sufficient amount to produce the proper chemical changes in the manure. Unrotted manure keeps the soil open, allows its precious moisture to escape, and burns the crop. For this reason many dry farmers in semi-arid America do not use stable manure.[47] The ancients met this difficulty by composting the manure for a year to insure its complete decay, soaking it with its own fluids or with water when it became too dry, and turning it frequently to admit the air.[48] The final product of this organic decay was humus or mould, which might be seen "passed through a sieve like so much flour, and perfectly devoid, through lapse of time, of all bad smell or repulsive appearance."[49]

[43] W. P. Brooks, *op. cit.*, II, 208.

[44] Pliny, XVIII, 53.

[45] Theophrastus, *Caus. Plant.*, III, 9, 2; *Hist. Plant.*, VII, 5, 1.

[46] Cato, 36; Varro, I, 38; Pliny, XVIII, 53.

[47] Wendell Paddock and Orville B. Whipple, *Fruit Growing in Arid Regions* (New York, 1914), 197.

[48] Columella, I, 6.

[49] Pliny, XVII, 6.

AMOUNT OF MANURE

From motives of economy and concern for a successful crop, the ancient farmer used no more manure than was absolutely necessary. "They tell us to manure a thin soil abundantly and a rich soil sparingly, both on account of the fertility of the soil and because the muck brings more nutriment than the land is able to take care of." Thus Theophrastus reports the general practice of farmers who feared the consequences of excessive manuring.[50] "It is better to manure little and often than in excess" was the Roman motto.[51] Therefore after a fallow season, when the ground would have partly recuperated its strength, manures were applied only to very poor land or to very exacting crops like beans, hemp, alfalfa and barley.[52] "Flax, oats and the sleep-giving poppy exhaust the soil, but it is easy to sow them in alternate years, provided you do not fail to soak the dry earth with rich muck and scatter foul ashes over the exhausted fields," says Vergil.[53]

The amount of manure customarily used under average conditions of soil and weather is specified by Columella. For a *jugerum* of hillside land 24 loads of 80 *modii*, or 492 bushels, sufficed; this equalled 788 bushels to the acre. On level land only 18 loads per *jugerum* or 525 bushels per acre were required, though the larger amount was used on a field prepared for a bean (*faba*) crop immediately after a grain crop.[54]

But weather conditions modified both the amount of manure and the method of its application; because a timely rain abated the danger attending excess. In an average autumn it was customary to manure the field just after a rain, then sow it, plough in seed and dung together, and then ridge and harrow;[55] but some farmers preferred to cast the manure and seed together.[56] The

[50] Theophrastus, *Caus. Plant.*, III, 20, 2. Compare Pliny, XVIII, 53.
[51] Columella, II, 16.
[52] Columella, II, 5, 10, 21, 23, 27, 31; XI, 2.
[53] Vergil, *Georg. I*, 77–81.
[54] Columella, II, 5, 16; Palladius, X, 1, 2.
[55] Columella, II, 10.
[56] Theophrastus, *Hist. Plant.*, VII, 5, 1.

interval left between the two operations was always short, because the dung was known to loosen and warm the soil, thereby stimulating germination.[57] Some farmers spread the manure between the upper and under soil, where it was easily reached by the rain and carried down to the roots of the plants, but where it was protected from the desiccating heat of the sun.[58] This method preserved not only moisture but also the important chemical constituents in the fertilizer. Cato advised scattering pigeon guano over meadow, garden or sown field, further to enrich the land.[59] Instead of the regular manuring, where this had been omitted, it was necessary to spread the land with aviary dust just before the mid-winter hoeing.[60] At that season the rains would carry this rich fertilizer down to the roots as a tonic to the crop.

Always loomed the danger of excessive manuring. This was known to kill trees and grain crops, unless they got a saving shower. Therefore in rainy localities, frequent and abundant manuring was safe and efficacious; but in arid districts or in thin dry soil a moderate application was the wise course,[61] and the avoidance of highly concentrated manures. To obviate all difficulty in a hot dry region, it was customary to fill the furrows or trenches with water and allow three days for its absorption, then throw the manure on this saturated soil, then plant and cover.[62]

MANURING AND IRRIGATION

Rich, concentrated manures, whose plant food was quickly available, were generally used in gardens and orchards which needed quick feeding; but to obviate the danger of burning, they were applied in diluted form or were combined with regular irrigation. In the Aegean lands night soil and swine dung were applied with irrigating water to pomegranate and almond trees to improve

[57] *Ibid.*, VIII, 7, 7.
[58] Theophrastus, *Caus. Plant.*, III, 6, 1.
[59] Cato, 36.
[60] Pliny, XVIII, 53.
[61] Theophrastus, *Caus. Plant.*, III, 9, 2.
[62] *Ibid.*, III, 6, 2.

the flavor of the fruit and reduce the size of the seed or nuts.[63] In Italy, pomegranate trees were watered four times yearly with diluted human urine at the rate of one *amphora* or seven gallons to the tree.[64] Columella advises this treatment for vines and various fruit trees to improve the flavor and aroma of the fruit.[65] All the waste from the olive oil presses, the amurca and the rotted lees were applied in the same way to fruit trees and vegetables;[66] and therefore Columella advised that gardens and orchards be located near the poultry yards, bagnios and olive waste receptacles.[67] But Theophrastus advised great discrimination in the selection of manures, "for the same manure is not equally suited to all kinds of trees. The age of the tree also makes a difference."[68] Even the organic waste from the currier's shop consisting of wool, hair and leather scraps was used for vines and fruit trees; but as this material was rich and rotted slowly, it too was combined with irrigation.[69]

Vegetables were equally avid of rich diluted manure. Theophrastus laid down the principle that all plants needing much nutriment needed also much water. Most vegetables germinated quickly, within five to ten days, and grew rapidly; hence their demand for food and ample water.[70] "All the pot-herbs are lovers of water and dung."[71] Both were necessary to cucumber and gourds.[72] When applied to cabbages in small quantities, they produced heads of the finest flavor; but in larger amounts, they produced larger heads of inferior flavor.[73] The truck gardens and olive groves about Athens were enriched by the sewage of the ancient city. The main *cloaca* or sewer ran across the city and through the Dipylon to a reservoir outside, from which

[63] Theophrastus, *Hist. Plant.*, VII, 51; *Caus. Plant.*, III, 9, 3; *Columella*, V, 10.
[64] Pliny, XVII, 47.
[65] Columella, II, 15.
[66] Cato, 93.
[67] Columella, I, 6.
[68] Theophrastus, *Caus. Plant.*, II, 9, 5; *Hist. Plant.*, II, 7, 3–4.
[69] Pliny, XVII, 46.
[70] Theophrastus, *Hist. Plant.*, VII, 1, 3.
[71] *Ibid.*, VII, 5, 1.
[72] Pliny, XIX, 24.
[73] Pliny, XIX, 41.

square or cylindrical brick-lined canals carried the contents to the intensively cultivated plain of the Cephisus valley, with its orchards and farms. One of these canals seems to show a device for regulating the flow, and suggests that the sewage was sold to the farmers.[74]

MINERAL FERTILIZERS

All this sounds modern and scientific. Still more does the ancient use of mineral fertilizers. These were found in their native state, either as earths like marl, or as deposits of alkaline salts like carbonate of lime and nitrate of potassium (nitre). Mixing different kinds of earth was first advocated by Theophrastus as "a means of remedying defects and adding heart to the soil."[75] Such mixtures improved both the chemical and mechanical composition of the soil, for the added ingredients were either direct or "indirect fertilizers." The value of alkaline earths was early recognized, notably in prehistoric Aegina, where their use became a theme of mythology. On this small and populous island the surface stratum of poor freshwater limestone was underlaid, one or two yards below, by a stratum of fertile marl. So the inhabitants pierced the sterile veneer, dug out the marl, mixed it with the soil above, or even spread it on the bare rocks to create a field.[76] This habit of burrowing underground and using the excavations as dwellings fastened on the early Aeginetans the name of Myrmedons or ants.[77] Likewise in nearby Megara, where a poor surface soil was underlaid by thick strata of various marls,[78] the same thing was done with good effect.[79]

The Romans imitated the practice of the Greeks and Gauls in the use of marl. They distinguished several varieties, and ap-

[74] Article on *Cloaca* in Smith, *Dictionary of Greek and Roman Antiquities* and Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft* (Stuttgart, 1901).

[75] Theophrastus, *Caus. Plant.*, III, 20, 3.

[76] C. Neumann and J. Partsch, *Physikalische Geographie von Griechenland* (Breslau, 1885), 348.

[77] Strabo, VIII, 6, 16.

[78] A. Philippson, *Der Peloponnes* (Berlin, 1892), 16.

[79] Theophrastus, *Caus. Plant.*, III, 20, 4.

plied them to grain and meadow lands, but they found the tufaceous and calcareous kinds the best for cereal crops. Like the modern farmers, they spread it very thinly on the ground to avoid burning, and found one such treatment sufficient for many years, though not fifty, as Pliny says. The white variety, if procured in the vicinity of springs (calcium carbonate) "rendered the soil immeasurably fecund for grain."[80] Columella advocated spreading marl on a gravelly soil or of mixing gravel with a dense calcareous soil, "as I have seen my uncle do. Thus he raised fine cereal crops and beautiful vineyards."[81] This uncle was a gentlemen farmer, a Roman colonist in Spain, who cultivated his estate near Corduba (Cordova) on the Guadalquivir River.

Lime was added to the soil in other forms, either as broken or powdered limestone, which was applied to orchards, vineyards and olive groves,[82] or as pumice stone and shells.[83] It was also provided by wood ashes, which were widely used as fertilizer in all parts of the Mediterranean region,[84] and which supplied phosphoric acid and potash as well as lime. Lime from the limekilns proved excellent for olive trees.[85] Some farmers living north of the Po and having a superfluous dung from their big herds of cattle, burned part of the manure by preference and applied the light ashes to the field.[86] Lime in any form was used to correct an acid soil. Sand was frequently mixed with a heavy clay or chalk soil to improve its mechanical composition in gardens and orchards,[87] and occasionally to facilitate drainage where the land had become saline.[88] Pliny disclaims any virtue in such a mixture, even when a red or black or white sand was combined with a rich earth.[89]

[80] Pliny, XVII, 4, 6–8.
[81] Columella, II, 16.
[82] Pliny, XVII, 4, 47.
[83] Vergil, *Georg. II*, 348–350.
[84] Vogelstein, *op. cit.*, 19–20; Pliny, XVII, 5, 47; Vergil, *Georg. I*, 80.
[85] Pliny, XVII, 6.
[86] Pliny, XVII, 5.
[87] Vogelstein, *op. cit.*, 19–20; article on horticulture in *Jewish Encyclopedia*.
[88] Theophrastus, *Caus. Plant.*, III, 6, 3.
[89] Pliny, XVII, 3.

Sometimes the soil needed other elements. Nitre (nitrate of potassium) and salt were found beneficial to certain vegetables; therefore they were either sprinkled over the garden plots or applied in solution to the plants.[90] Radishes, beets, rue and asparagus were among the vegetables so benefitted both in flavor and growth.[91] Nitre removed the excessive pungency of radishes, and increased the size of beans.[92] Palm trees, which were known to require a saline soil, were treated with salt or brine about their roots.[93]

GREEN MANURE CROPS

The drawback of these mineral fertilizers was their failure to supply humus, which was especially needed on arid soils and on clean-cultured fallow land. Hence the ancients scarcely relied on them to take the place of animal manures; but they devised instead by 400 B.C. or even earlier a system of green manure crops, which was also an improvement on the old fallow field system. Xenophon states that a green crop ploughed in enriches the soil as manure does,[94] but he does not specify the kind of crop. Theophrastus, however, reports that the farmers in Thessaly and Macedonia raised a bean crop and turned it under when it was in flower; because the bean (faba vicia) reinvigorated the soil, even when it was sown thickly and produced much grain. The reason he assigned for this effect was that "the plant was of loose growth and decayed quickly."[95] In his later book he makes the generalization that legumes do not take strength from the cultivated land but rather give it new strength. He made an exception however in the case of chick peas, because they required rich black soil and only served to exhaust the land.[96] In this opinion Cato concurred, specifying field beans, lupines and vetch as the best green manures for grain crops.[97] For thin soil Varro advocated ploughing in

[90] Pliny, XIX, 41; *Luke*, XIV, 35; Theophrastus, *Caus. Plant.*, III, 7, 8.
[91] Pliny, XIX, 59.
[92] Pliny, XIX, 26; Vergil, *Georg. I*, 194.
[93] Theophrastus, *Caus. Plant.*, II, 5, 3; III, 7, 1–4.
[94] Xenophon, *Oeconomicus*, XVII, 10.
[95] Theophrastus, *Hist. Plant.*, VIII, 7, 2; IX, 1.
[96] Theophrastus, *Caus. Plant.*, IV, 8, 1–3.
[97] Cato, 37 and 54.

snail clover or beans before they began to pod.[98] Columella enumerated lupines, beans, vetches, lentils, chick peas and other pea varieties as renovating crops, provided they were ploughed in as soon as the green fodder crop was harvested, before the fresh roots should become dry and withered. Clover and alfalfa, after they had yielded fodder for their appropriate number of years, were turned under when the crop began to deteriorate.[99]

All the ancient authorities agreed however that the most economical and satisfactory green manure crop was lupines; it would thrive on dry, sandy, or gravelly soil or on *terra rossa*,[100] gave food for man and beast, was cheap to seed, quick to grow, blossomed three times; and to enrich the ground should be ploughed in just after the third flowering, or if planted on sandy soil, after the second flowering.[101] Moreover it was so vigorous that it competed successfully with weeds and underbrush.[102] Green lupine stalks enriched the soil exceedingly.[103] This ancient estimate of lupines as a green manure crop is sustained in every point by modern scientific agriculture.[104]

By age-long experiment the ancients learned the power of legumes to open up and mellow the soil by their thick, deep-running roots; to keep down weeds by their thick cover growth and deeper roots; to put more nutriment into the soil than they took out of it; to increase the farm income by substituting a food crop for an idle fallow which demanded constant tillage; and especially the great economic profit in growing legumes like lupines or vetch, which would thrive on poor dry soils, as compared with chick peas which required a rich heavy loam. The ancients reveal a deep understanding of the manurial value of green legume crops, when they raised mixed fodder crops of legumes and grains;[105] and especially when they "found it very

[98] Varro, I, 23, 2–3; Pliny, XVIII, 30.
[99] Columella, II, 10 and 14.
[100] Theophrastus, *Hist. Plant.*, VIII, 11, 8; *Caus. Plant.*, IV, 7, 3.
[101] Columella, II, 10; XVII, 6; Pliny, XVIII, 36.
[102] Theophrastus, *Hist. Plant.*, I, 7, 3; VIII, 11, 8.
[103] Columella, II, 15; Pliny, XVII, 6.
[104] W. P. Brooks, *op. cit.*, II, 360.
[105] Varro, I, 31; Pliny, XVIII, 41–42.

profitable to sow garlic and onions between the rows of cytisus or snail clover,"[106] thereby anticipating the interculture of vegetables and legumes practiced today in intensive Japanese horticulture.

The ancients achieved results without chemistry and bacteriology, which have revealed the nitrogen-gathering bacilli harbored by the roots of legumes. These fix the free atmospheric nitrogen and incorporate it in the soil in the form of nitrates; thus they capture the most valuable and elusive element of plant food. The successful cultivation of legumes in all Mediterranean lands from earliest times indicates that the necessary bacteria were widely distributed. But the mixing of soils of different kinds, advocated by Theophrastus, may have owed its efficacy, so far as legumes were concerned, to the inoculation of the field with the necessary bacteria. This method of preparing land for clover crops has been practised in Kentucky for a hundred years or more, by borrowing a few barrels of soil from a neighbor's clover field; and it is now advocated by the United States Department of Agriculture.[107] Finally the ancients did not plough in the legume crop till the plants gave signs of podding; they postponed the operation till the critical date, taught only by long experience and observation. Modern laboratory experiments show that legumes of all kinds take nitrogen from the air in largest proportion as they approach maturity; so the ancients had sound basis for their practice.[108]

ROTATION OF CROPS

Rotation of crops was apparently inaugurated by the alternate planting of grains and legumes. Rye was the only other crop definitely used to enrich the soil; but its use for this purpose came in late and was restricted to the upper Po Valley where the grain found a favorable rainfall.[109] But Pliny also indicates the ploughing in of millet and panic in the Alpine piedmont to ferti-

[106] Pliny, XIII, 47.
[107] J. M. Westgate, "Alfalfa," *Farmers' Bulletin 339* (Washington, 1908), 17–18.
[108] W. P. Brooks, *op. cit.*, II, 365.
[109] Pliny, XVIII, 40.

lize the soil; he states that this was done just as the stem began to develop or had put forth two or three leaves.[110]

Otherwise, rotation of crops made limited progress. Varro advised that, in lieu of the fallow, the land be planted lightly with some other crop less exhausting than grain.[111] The fertile Neopolitan plain was cropped all year round, once with panic, twice with spelt, and occasionally a fourth time with vegetables,[112] —a series not calculated to conserve plant food. Pliny gives another rotation suited to black, friable soil of the kind described by Cato as "tender;"[113] first barley, then millet, then rape, and finally barley again or wheat, with no cultivation between beyond ploughing when the seed was sown. Yet another rotation was spelt succeeded by a four-months' winter fallow, then spring beans, then winter beans.[114] This series provided amply for the compensation of the soil. The Romans had an effective system to renovate a worn-out meadow. After thorough ploughing, the field was planted in beans, rape, or millet, the next year in wheat, and the third year in some hay crop like clover or grass.[115] An old tenant's contract of Palestine in Mishnah times provided that barley should be raised the first year, onions the sixth of the Sabbatical cycle, and flax one year between; but beyond this it indicated no system of rotation.[116] Greek authorities mention only the alternation of legumes and grain.

Despite Vergil's generalization that "the fields rest by a change of crops,"[117] rotation was little practised. This was the weak spot in ancient agriculture. It may have resulted from the conservative allocation of crops to selected terrains and soils, combined with the prevalence of small, naturally defined districts, in which exchange of crops between different fields was difficult or economically impossible. Consequently the persistent discrimination in

[110] Pliny, XVIII, 49.
[111] Varro, I, 44, 2.
[112] Strabo, V, 4, 3; Pliny, XVIII, 29.
[113] Cato, 151.
[114] Pliny, XVIII, 52.
[115] Pliny, XVIII, 67.
[116] Vogelstein, *op. cit.*, 50.
[117] Vergil, *Georg. I*, 82–83.

the use of certain soils for certain crops tended to crystallize into a rigid system. Rotation was restricted before it could advance. General farming, with balanced stock-raising and diversified field agriculture on a fairly ample scale, developed only in regions of low relief and abundant water, like the Nile and Po valleys; or in smaller districts of moderate relief and high fertility, like the hill-and-dale country about the old volcanoes of Etruria and Sicily, or like the productive lake basins of Greece. Moreover, the large area in all Mediterranean lands devoted to permanent plantations of orchards and vineyards contributed to this fixation of crops by restricting the arable land susceptible of rotation. The fallow system worked to the same end by halving the amount of land available at any one time for field agriculture. The result was the constant danger of over-cropping, and the steady evolution of manuring to safeguard the soil from exhaustion.

SEED SELECTION

The principle of seed selection was early advocated by the ancient farmers as a prime means of improving crops; and in the first decades of the Roman Empire it reached a development which has only recently been attained in America. This gospel, now preached by agricultural colleges, was adumbrated in the Hebrew Scriptures. The biblical injunction, "Thou shalt not sow thy field with mingled seed"[118] was evidently intended to make the Judean peasant scrutinize his seed corn and eliminate adulterations, in order to get a clean crop. It was a kind of precautionary weeding. But the sorting process inevitably led to the rejection of imperfect specimens of the desired grain, and hence was an initial step in seed selection. The injunction, which is found in Leviticus, dates back to the eighth or nineth century B.C., and like other agricultural methods was probably borrowed from the local Canaanites; for the early folk tale of Ishobeth describes the door-keeper of the Israelite prince, drowsing in the noonday heat over his task of cleansing wheat for his master.[119] The practice

[118] *Leviticus*, XIX, 19; *Deut.* XXII, 9.
[119] *II Samuel.* IV, 5–6 (revised version).

was still current in the time of Josephus;[120] and in the New Testament the sowing of "good seed" is stressed.[121]

Jewish farmers, in the first and second centuries of our era, planted seed beds for the purpose of getting a superior quality. The plain of Jericho was divided up into numerous small plots of wheat and barley; for the soil was rich on this old river terrace of the Jordan, and irrigation from spring or reservoir insured sufficient water. Elsewhere whole fields were cut up into beds, each planted with a different seed. The Jews carried on a trade in seed-corn and made purchases by tested seed or by samples, much like the little trays of wheat carried about the market by the grain merchants of ancient Athens. They tested seed by planting a few in an earthen pot or a manure bed, and judged the vitality by the rapidity of germination.[122] This method recalls the miniature "gardens of Adonis," offered to the youthful god of spring throughout Syria from remote times. They consisted of seedling grains or vegetables raised in earthen pots by some forcing process, and may possibly have been either cause or effect of early experiments in seed testing.

The principle of seed selection emerges more clearly among the ancient Greeks. Aristotle observed that a good plant was not likely to grow from a bad seed, nor a bad plant from a good seed,[123] under proper conditions of climate and soil. Theophrastus voiced a general opinion of Hellenic farmers that seeds of herbs and vegetable collected from plants in their prime showed their superior vitality by rapid germination. Hence when the plants were at their best it was customary to gather the seed and dry them, since well cured seed were known to produce more fruit.[124] Theophrastus also stressed the importance of the youth of the seed: for all crops, whether grain or vegetables, the seed of the year was considered the best; next best was that of the previous year, and poorest that of the third year before. Beyond this the

[120] Josephus, *Jewish Antiquities*, BK. IV, chap. viii, 20.
[121] *Matthew*, XIII, 24–30.
[122] Vogelstein, *op. cit.*, 38–43.
[123] Aristotle, *De Plantis*, I, 6; II, 6.
[124] Theophrastus, *Hist. Plant.*, VII, 3, 3–4.

seed was likely to be sterile, though still suitable for food. Some exceptions to this rule depended upon the locality of production and preservation; for in high, windy regions seed seemed to retain their vitality longer.[125] Age affected the rapidity of germination also in garden plants. Fresh seed in general sprouted more quickly, though celery, beet, coriander, parsley and some others came up more promptly from older seed.[126] Moreover, the Greek farmers discovered that all vegetables were greatly improved in size and quality by transplanting; therefore they took special care to transplant those reserved for seed collection.[127] A similar tendency to coddle seed nurseries prevailed in Italy. Pliny states that cabbage plants intended for seed were never cut.[128] Cato devoted great care to his seed-plots.[129]

The Greeks experimented with choice seed from different countries, in consequence of the extensive importation of over-sea grains, fruits and vegetables. For instance, a three-months Sicilian wheat was tried in Achaia, where it failed to yield a crop; but it was raised successfully in the southern part of the island of Euboeia, which was exposed to the warm, rainy south wind (Notos) of spring. Experiments with seeds from various climates and soils about the Mediterranean shores led to an interesting generalization formulated by Theophrastus: "Each seed of the several seed kinds is adapted to the natural conditions of its native habitat, both genera as compared with genera and the different species of the same genus. It is wise to transfer seed from a warm region to one a little less warm, and from a cold region in the same way. . . . . Those which are transplanted from far northern lands to a hot district unfold their flower so late that they are caught by the summer drought, unless they are saved by the late rains of spring. Wherefore, according to the general opinion, care should be taken to prevent them from becoming mixed with the local variety, unless they come from

[125] *Ibid.*, VII, 5, 5; VIII, 11, 5. Compare Pliny, XVIII, 54.
[126] Theophrastus, *Hist. Plant.*, VII, 1, 6. Compare Pliny, XIX, 35.
[127] Theophrastus, *Hist. Plant.*, VII, 4, 3; VII, 5, 3.
[128] Pliny, XVIII, 62; XIX, 41.
[129] Cato, 40.

similar climatic conditions; for otherwise they are hardly suited to the new region in regard to their time either of sowing or sprouting."[130] In regard to soil he says: "Seed, like fruit trees, ought to be brought from similar or poorer land, so that the change made is none at all or for the better. However, they maintain that seed sprung from good soil are more vigorous and maintain this virtue for two years. But differences of climate must also be considered. Seed sprung from a sunny, warm region should not be sown in a late chilly region, nor vice versa. The former come out too early and are nipped by the lingering cold; the latter too late, and perish in the heat and drought."[131] Most of these instructions anticipate the modern practice.

The Romans fell heir to the Greek attainments in the art of tillage, and carried the principle of seed selection yet farther. They recognized it as the chief means of keeping a crop true to type. "Seed though long chosen and carefully approved still degenerate unless the largest are selected year after year by the hand of man," says Vergil.[132] Siligo, a choice winter wheat, was broadly planted in the moist alluvium of Italy; but across the Alps it remained constant to type (*pertinax*) only in the fertile soil and mild climate of the middle Rhone and Isere valleys. Elsewhere in Gaul it reverted after two years to the common local variety, unless only the heaviest grains were selected for sowing.[133]

Large and heavy seed were known to be the best. Moreover these had to be fresh, clean, free from alien admixtures.[134] Therefore wheat and barley grains which by reason of their weight settled to the bottom of the threshing floor or cleansing sieve were reserved for seed. "This is very necessary because all cereals tend to degenerate." Moreover, only the largest and best ears of wheat and other grains were reserved for seed corn.[135] "Ears of the finest and best grain should be taken to the threshing

[130] Theophrastus, *Hist. Plant.*, VIII, 8, 1.
[131] Theophrastus, *Caus. Plant.*, III, 14, 1-2; Pliny, XVIII, 54.
[132] Vergil, *Georg. I*, 197.
[133] Pliny, XVIII, 8.
[134] Varro, I, 50.
[135] Columella, II, 9.

floor and kept separate from the rest, so that the farmer may have the best possible seed."[136] Ears with vacant spaces between the grains were rejected. This is the modern "ear selection." Moreover, the grains themselves were tested by color, outside and in, especially for the red and the white wheat.[137] There was a special test for lentil seed, which were often eaten by weevils, even in the pod. Therefore after the lentils were threshed they were thrown into tubs of water. The empty or weevil-eaten ones floated, and those which sank to the bottom were dried in the sun and kept for seed.[138]

AMOUNT OF SEED

The amount of seed sown to the *jugerum* varied according to the soil, location, exposure to wind and sun, time of sowing and also according to the kind of seed. A good rich soil could stand heavier seeding than a poor, thin, sandy soil;[139] for the latter if too thickly sown, yielded a small and empty ear.[140] The average amount broadcast on medium soil was 5 *modii* of wheat, 10 of spelt, and 6 of barley per *jugerum*, or 8, 16 and 10 pecks respectively to the acre.[141] These figures correspond fairly well with the modern English practice but exceed the American requirements when the seed are put in with the drill. The ancients themselves recognized that all seed made better growth when set or planted, than when scattered;[142] and hence employed the more careful method in their seed-beds, using fewer to the plot.[143] As opposed to the average 5 *modii* of wheat per *jugerum*, 4 *modii* sufficed on loose, fertile well-drained land, but 6 modii were required for the less productive, dense, cretaceous soil; because a rich soil made the grain stool freely and so yielded a thick crop for a light sowing.[144] The thrifty Mediterranean farmer was

[136] Varro, I, 52.
[137] Pliny, XVIII, 54.
[138] Columella, II, 9.
[139] Xenophon, *Oeconomicus*, XVII, 8–11; Theophrastus, *Hist. Plant.*, VIII, 6, 2.
[140] Pliny, XVIII, 55.
[141] Columella, II, 9.
[142] Theophrastus, *Hist. Plant.*, VII, 5, 3.
[143] *Ibid.*, VII, 4, 3.
[144] Pliny, XVIII, 55.

always ready to save his seed corn; but he knew it was poor economy to "rob the harvest" by under-seeding his field on which much labor had been spent.[145] Moreover, the seed was sown thick if put in early in the autumn, because it had to wait some time for the rains before germination and would not stool abundantly; when put in later just in time for the rains, it was sown thinly "to prevent it from being suffocated," because the plants were large and thick.[146]

Indirect testimony to the intensive character of ancient Mediterranean tillage is furnished by certain maxims that embodied old agricultural standards. The ideal was the small freehold estate, cultivated with infinite care under the master's personal supervision. The Judean national dream was every man established on a bit of land where he could rest "under his own vine and his own fig-tree," when the day's work was over. "He that hath a little garden and fertilizes it and digs it, and enjoys the produce is far better off than he who works a large garden on shares," was an ancient rabbinical comment on freehold versus tenant farming. Another was a precept for personal supervision: "He that inspects his field daily will find a stater in it."[147] Later Cato paraphrased this motto when he said that on a farm "the master's forehead is of more use than his back."[148] So also Mago of Carthage, who formulated Phoenician tillage practice in the fifth century before Christ, stated that a person buying a farm ought to sell his town house and live in the country.[149]

In the Homeric poems, the cultivated estates of princes and kings were of moderate size, though they were supplemented by broad pasture lands which were frequently communal. The reward promised to Meleager by the people of Caledon for a great public service was "a fair demesne of 50 *guai*, the half thereof vineyard and the half open plough-land" located in the fertile Calydonian plain.[150] The garden of Alcinous in the little island

[145] Cato, 5.
[146] Pliny, XVIII, 54.
[147] Article on agriculture in *Jewish Encyclopedia*.
[148] Cato, 4.
[149] Mago quoted in Pliny, XVIII, 7.
[150] *Iliad.*, IX, 578–581.

kingdom of Scheria comprised four *guai*, laid out in vineyard, orchard, and vegetable plots.[151] The question is the size of the *gues*, which apparently corresponded to the yoke of the Hebrews and the *jugerum* of the Romans, or the area ploughed by a single yoke of oxen in one day or rather half a day. It has been variously estimated as approximately half an acre by Seymour[152] and as four-fifths of an acre by Ridgway;[153] but Seebohm would cut the latter estimate in half.[154] Hence the garden of a great king comprised only two acres, and Meleager's estate measured from 20 to 40 acres, in a time when Greece was sparsely populated. The peasant holdings in Boeotia in the eighth century B.C.were apparently very small, because Hesiod wanted only one son, that he might inherit the entire farm.

The scale of land holdings in Attica under Solon (594 B.C.) corresponds with that of the legendary period in general.[155] (I) The great land owner, judging from the yield of his farm, had 75 to 125 acres of grain land, or 20 to 25 acres of vineyard, or 50 to 75 acres of mixed lands. (II) The Knights forming the second class of big proprietors owned 45 to 75 acres of grain land, or 12 to 15 acres of vineyard, or 30 to 45 acres of mixed lands. (III) The Zeugites or medium proprietors owned 30 to 50 acres of crop land, allowing for the alternate years of fallow, or 7 to 10 acres of vineyard, or 25 acres of mixed lands. (IV) The Thetes had 22 acres at most if he raised grain, or 6 acres of vineyard, or 15 acres at most if he carried on mixed farming.[156] Thus the maximum estate in Attica was small, when the people were groaning over the appropriation of the land by the plutocrats. A century and a half later the sub-division of farm land had progressed. The paternal inheritance of Alcibiades was only 300 plethra or 70 acres, though he was accounted rich. The recorded sales of estates indicate many small plots or dwarf farms under 14 acres. The few large holdings were located on the frontier

[151] *Odyssey*, VII, 113.
[152] T. D. Seymour, *Life in the Homeric Age* (New York, 1907), 245–246.
[153] W. Ridgway, *Journal of Hellenic Studies*, VI (1885), 321–326.
[154] F. Seebohm, *Customary Acres* (London, 1914), 194–202.
[155] Plutarch, *Solon*, XVIII.
[156] G. Glotz, *Ancient Greece at Work* (New York, 1926), 247.

remote from Athens or in the mountains where the land was rough and fit only for forest.[157] One such, which became involved in a lawsuit in the time of Demosthenes, is the largest reported, and comprised about 778 acres. It had about 300 acres in barley and 50 acres in vineyards, but it also drew a large revenue from the wood carried daily to the city by six asses.[158] Public opinion opposed the concentration of real estate, as indicated by Plato in his *Laws*, where the maximum property should not contain more than four single lots.[159]

It was on these small farms that the Attic farmers practised agriculture as Theophrastus observed it. The pressure of poor soil and meagre rainfall is revealed in the intensive methods there developed. Add to this the pressure of a dense urban population engaged in trade and industries, and relying on the local farmers for fresh vegetables, fruits and flowers, even though most of the breadstuffs came from overseas. Similar conditions held in various other parts of Greece and in the Aegean Islands, with similar effects upon land holdings[160] and tillage methods.

In contrast to Greece and Palestine, ancient Egypt at the zenith of its power doubtless approximated the arable area of 12,000 square miles which the country commands today. Land tenure on a big scale prevailed, owing both to the geographic conditions of ample fertile soil and abundant water for irrigation, and even more to the social organization of the state. But the very fecundity of the Nile Valley induced a density of population which became excessive and therefore enforced careful tillage, especially the extension of the irrigable area, against periods of famine in years of "low Nile."

In Italy again, where typical Mediterranean conditions of climate and relief prevail, tillage adjustment is apparent in the small freehold farms which were the rule, so long as the Roman

[157] A. Boeckh, *Public Economy of the Athenians* (trans. from the German, Boston, 1857), 88–91.

[158] Demosthenes, *Oration against Phaenippus* (trans. by C. R. Kennedy, Bohn Library, 1901), IV, 290–303.

[159] Plato, *Laws*, V, 13.

[160] H. Blümner, *Life of the Ancient Greeks* (trans. from the German, London, 1895), 493.

territory was small. Prior to the Second Punic War, the land allotments of the free peasants were variously two, three, seven, ten, and fourteen *jugera* of tillage land with the right of pasturing cattle on the public domain. Cincinnatus was ploughing his four-*jugera* estate on the Vatican Hill, when called to be dictator in 458 B.C. A farm of seven *jugera* or four and a half acres was considered ample for an industrious peasant by conservative Romans.[161] This was the plebeian allotment in the early Republic and it was confirmed by the Consul Curius Dentatus in 289 B.C.[162] It corresponds to the "four acres and a cow" warranted by rural enthusiasts to support the modern farmer, if he practises scientific agriculture and locates near a big urban market.

The small farm, cultivated with intelligence and industry, remained the agricultural ideal of the Romans long after rapid territorial expansion and protracted military service had undermined the little peasant freehold in old peninsular Italy. Colonial allotments did not exceed ten *jugera* or six and a quarter acres till the time of Tiberius Gracchus (133 B.C.), except in Latin colonies planted on remote, exposed frontiers. In such cases larger land grants compensated the settlers for the danger incurred. Bononia was founded as a fortified colony in 189 B.C., among the recently conquered Boii, to guard the only direct road across the Apennines by the Futa Pass, maintaining connections between Rome and the Po Valley. Hence the infantry received 50 *jugera* or 31 acres each, and the cavalry 70 *jugera* or 43 acres.[163] Similar large allotments were made at other danger points, like Aquileia at the foot of ominous Carso,[164] and Luna which was meant to police the Ligurian raids from the Apennines.[165]

The agrarian law of Gracchus provided land grants of 30 *jugera* or 18.7 acres for about 80,000 Roman citizens, and thus inaugurated a larger scale of land holding for the masses. August Meitzen, on the basis of all colonial allotments in ancient Italy,

[161] Livy, *Historia*, V, 30.
[162] Valerius Maximus, IV, chap. iv, 6–7.
[163] Livy, XXXVII, 57.
[164] Livy, XL, 34.
[165] Livy, XXXIX, 1, 2; XL, 38, 41.

concludes that Roman citizens with full privileges held estates of 30 to 70 *jugera* or 18 to 44 acres, and that plebeian farms ran from 7 to 20 *jugera* or 4.5 to 12.5 acres.[166] These were probably the general conditions familiar to Cato, though as a big landed proprietor of this century (died 149 B.C.) he considered a 100 *jugera* vineyard (62 acres) and a 240 *jugera* olive grove (150 acres) a reasonable estate.[167]

Yet the little peasant farm tended to revive on fertile soil in populous districts, where careful garden and fruit culture would give the proprietor a living. When a distribution of the public land about Capua and the Stellas Plain in Campania was contemplated in 59 B.C., Cicero said the land could not support more than 5000 colonists, "so as to give them 10 *jugera* apiece,"[168] as if that amount would suffice. On this area of 50,000 jugera some 20,000 citizens were settled later, according to Suetonius. Figures like these, compared with colonial grants in modern Africa and the Americas, illuminate the whole question of agricultural methods and arable area in the Mediterranean lands.

All efforts to check the decay of tillage in Roman Italy stressed the old standards of intensive cultivation. "Praise big estates but cultivate a small one" was Vergil's advice.[169] Pliny quotes the ancient adage that it was wiser to sow less and plough more.[170] Columella applied the Greek maxim of "measure in all things" to land holdings, as he enunciated the economic principle that a large farm poorly cultivated yielded less profit than a small one well tilled; and he fortified his opinion by a precept of Mago of Carthage, that a husbandman ought to be more than a match for his farm, so that when he grappled with its problems he should come out ahead in the encounter.[171]

Nature gave the ancient farmer the privilege of the struggle. Under the influences of climate and relief was evolved a system of tillage, which produced: (I) Winter grain crops maturing in

[166] August Meitzen, *Siedelung und Agrarwesen* (Berlin, 1895), I, 255.
[167] Cato, 2 and 10.
[168] Cicero, *Litterae ad Atticum*, A. II, 16.
[169] Vergil, *Georg. II*, 412.
[170] Pliny, XVIII, 7.
[171] Columella, I, 3.

spring or early summer. (II) Planted crops of olives, figs and grapes ripening in autumn without artificial watering. (III) Widely distributed summer crops of fruits, vegetables and fodder plants raised by irrigation, wherever springs and perennial streams were available. The immediate material gain of this triple system was a larger and more certain total harvest and a more varied food supply than the single seasonal cultivation could have yielded. More important, however, was the economic gain, because it meant improved economic methods. It involved increased application of capital for seed, manures and the construction of irrigation canals; and it demanded an elaborate and sustained system of farm work, in consequence of which the labor power of the community was kept employed all the year round.

The economy of national wealth and the gain in national efficiency were incalculable. There was no economic leakage incident to supporting the rural labor in idleness during half the agricultural year; for Mediterranean conditions of climate and relief rendered possible a vegetative year of twelve months. Therefore Varro and Xenophon show the ancient farmer with his slaves hurrying from one urgent agricultural task to another.[172] Harvest followed fast upon harvest all through summer from April to October; and the October harvest crowded upon the heels of the autumn ploughing and sowing. The days of plenty predicted by the prophet Amos, "when the ploughman shall overtake the reaper and the treader of grapes him that soweth seed,"[173] describes the ideal of productive activity in farm life, not only in Palestine but in other Mediterranean countries. Thus under the prick of Nature's goad, primitive society in these lands began early to develop a capacity for sustained labor, which was at once evidence and guarantee of rapidly advancing civilization.

[172] Varro, I, 29–36.
[173] *Amos*, IX, 13.